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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CVIII.—No. 2799.] *LONDON: FRIDAY, AUGUST 22, 1919.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...9d. BY INLAND POST ... 11d.

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STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 7607

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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.
See Advertisement, page 33, last week.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

John H. Wilson & Co., Ltd.
Birkenhead.
See Illustrated Advertisement Page 114, July 18.

Locomotive Shunting Cranes
Steam and Electric Cranes,
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS WINDLASSES, WINCHES, and DECK MACHINERY.
6770
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Gas and Oil Engine Repairs.
—H. J. DAVIS & CO., Great Eastern Road, Stratford, E. 15.
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Manufactured by
PETTERS LIMITED, Engineers, Yeovil.
See our illustrated Advt. every alternate week. 3591

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For class of Machine Tools see our Illustrated Advertisement every alternate week. 1358

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HIGH-CLASS ENGINES FOR ALL PURPOSES. also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
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GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 7364
Telegrams—"Cylinders," Birmingham.

Weldless-Steel Tubes
for Water-tube Boilers, Superheaters, Shafting, Hydraulic Work, Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. 8179

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS, GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 6676
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SPECIALISTS IN
Drillers & Boring Machinery
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Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17, Aug. 15. 7263

Electric Cranes.
7182
S. H. HEYWOOD & CO., LTD., REDDISH.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 6961

Tank Locomotives
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 7360

AUTOMATIC ANALYSIS OF FLUE GASES.
Hays CO_2 Recorders,
Draught Gauges, Gas Analysers, Gas Collectors
Tested out on the High Seas in Naval Ships.
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Telegrams— Fuelecon, 'Phone, London. *Telephone*— 4280 Victoria.

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FROM 50 TO 600 YARDS PER HOUR.
D. Whitaker,
1, UNION STREET, LEICESTER. 6263

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Steel Castings.
7379
See displayed advertisement every alternate week.
JOHN M. HENDERSON & CO., ABERDEEN.

"Spencer-Hopwood" Patent
Sole Makers:
Boilers.
W. H. SPENCER & CO., HITCHIN, HERTS.
See page 18, Aug. 15 7454

Henry Wells Oil Co.,
11, HAYMARKET,
London, S.W. 1.

"Aptol" Lubricants.
WORKS: SALFORD, MANCHESTER. 7184

Iron and Steel
Tubes and Fittings.
8020
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 97.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, } Row's Patents.
CONDENSERS, AIR HEATERS,
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 6723

Tubes and Fittings,
IRON AND STEEL.
Stewarts and Lloyd's, Ltd.,
41, OSWALD ST., GLASGOW.
BROAD STREET CHAMBERS, BIRMINGHAM; and LONDON OFFICE—
WINCHESTER HOUSE, OLD BROAD STREET, E.C.
LONDON WAREHOUSE—167, UPR THAMES ST., E.C.
LIVERPOOL WAREHOUSE—63, PARADISE ST.
MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—132, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHEEPSCOTE STREET, and 10, COLESHILL STREET.
See Advertisement page 28. 7368

Die Finished Castings ensure rapid production and reduce prime cost by eliminating machining operations. Write for illustrations to AERATORS LTD., Belmonton, London, N. 18.

B.F.A. Fire Extinguishers
are foremost as fire fighters. No Acids. No Alkalis. Safe to use and always ready.—BRITISH FIRE APPLIANCES Co., Ltd., 109, Victoria St., London, S.W. 1.

R. Heber, Radford, Son & Squire,
ENGINEERING, IRON AND STEEL WORKS
Valuers.
CONSULTING ENGINEERS, REFEREES, AND ARBITRATORS.
Established over 50 years. 7108
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Telegrams: "Radford, Sheffield." Telephone: 425.

Locomotive Traversers
(ELECTRIC).
7182
S. H. HEYWOOD & CO., LTD., REDDISH.

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED.
Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See Illus. Advt. last week, page 18. 7046

Patent
See's Hydro-Pneumatic **Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

Separators
— FOR —
EXHAUST STEAM TURBINES COMPRESSED AIR, &c.
STEAM DRYERS,
METALLIC PACKINGS.
Princeps & Co., 6686
SHEFFIELD.

Delivery from Stock:—
NEW 8½-IN. CENTRE HIGH-SPEED LATHES.
BECKER BRAINARD VERTICAL MILLER.
No. 2 KEMPSMITH UNIVERSAL MILLER.
JOHN MACNAB, MARY STREET, HYDE.
Tel. No.: 78 Hyde. 7776

Rubber MANUFACTURERS.
Hose Suction and Fire.
GUTTA PERCHA & RUBBER, LIMITED.
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CHANTIERS & ATELIERS
Augustin-Normand
67, rue de Perrey—LE HAVRE (France).
3800
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating, Diesel Oil Engines.

Yarrow Patent
Water-Tube Boilers.
6094
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS, 1916
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 2383

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 27, Aug. 15. 2466

A Time Recorder Wanted,
State price and where can be seen.—BOX T.R., SMITH'S Advertising Agency, Ltd., 100, Fleet Street, London, E.C. 4. W 464

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, GLASGOW. Od 6641
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Steel Castings.
THOMAS SUMMERSON & SONS, LTD.,
DARLINGTON. 6974

Electric Transporters.
S. H. HEYWOOD & CO., LTD., REDDISH. 7182

Gauges
FROM
Stock.
THE
Newall Engineering Co.
(Proprietors, Peter Hooker, Ltd.),
LONDON, E. 17. 7324

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 7312

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 7008
See half-page Advertisement page 94, Aug. 8.

B. & S. Massey, Ltd.,
MANCHESTER.
Steam Hammers,
Power Hammers,
Drop Stamps,
Band Saws. 7206
QUICK DELIVERY. LARGE STOCK.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 7479

THE ROYAL ADMINISTRATION OF THE SWEDISH GOVERNMENT RAILWAYS,
STOCKHOLM,

Herewith Announces the

Result of the Prize Judgment

of the
OPEN INTERNATIONAL PRIZE COMPETITION,

noticed by the Royal Administration regarding proposal to a Railway Bridge for the West Mainline over Hammarbyleden, at the "Årsta" Islets in Stockholm.

The Prize Tribunal, appointed by the Royal Administration has decided to grant:

1st Prize Sw. Krs. 15,000 to Proposal No. 9
"Simplicitas,"

2nd Prize Sw. Krs. 10,000 to Proposal No. 14
"Ueber Land und Wasser,"

3rd Prize Sw. Krs. 5,000 to Proposal No. 32
"Hammarbyleden."

For those for purchase, granted Sw. Krs. 5,000, the Prize Tribunal has decided to buy:

Proposal No. 3,
"Sic vero mihi placet" for Sw. Krs. 2,500.

Proposal No. 15,
"Bifrost" for Sw. Krs. 2,500.

On opening the name slips, for with prize rewarded and for purchase for already granted means recommended proposals, the corresponding authors proved to be:

To that with First Prize rewarded, Proposal No. 9, "Simplicitas."

Maschinenfabrik Augsburg-Nürnburg A.G., Werk, Gustavsburg, in Gustavsburg, b/Mainz.
Dückerhoff & Widmann A.G., Tiefbau-Unternehmung, Biebrich, a. Rhein.
Aktiebolaget Arcus.
Arkitekt, Sven Jonsson, Stockholm.
Olof Lundgren.

To that with Second Prize rewarded, Proposal No. 14, "Ueber Land und Wasser."

Brokonstruktionsbyrån Nilsson & Co.
Ernst Nilsson.
Nils Bolinder.
Gustaf Cervin.
K. Martin Westerberg, Arkitekt.
S. Kasarnowsky.

To that with Third Prize rewarded, proposal No. 32, "Hammarbyleden."

Fried. Krupp A.G.
Friedrich-Alfred-Hütte, Abtlg. Eisentauwerkstätten Rheinhausen (Niederrhein).
Grün & Bilfinger A.G., Mannheim.
Fried. Krupp A.G., Bauverwaltung, Essen-Ruhr.

To the First Purchased Proposal No. 3, "Sic vero mihi placet."

H. Kreuger and O. Linton.
Otto Linton, Stockholm.

To the Second Purchased Proposal, No. 15, "Bifrost."

Aktiebolaget Skånska Cementgjuteriet, Stockholm.
A/S Titan, Kopenhamn.
Arkitekt: Torben Grut.

Moreover, the Prize Tribunal has decided to suggest to the Royal Administration to apply for means for the purchase of:—

Proposal No. 29, "Plåtbåge," for Sw. Kr. 2500.
" No. 10, "Völund," for Sw. Kr. 2500.

THE ROYAL ADMINISTRATION
OF THE
SWEDISH GOVERNMENT RAILWAYS.

X 930

CRYSTAL PALACE
SCHOOL OF PRACTICAL ENGINEERING.

Principal: J. W. WILSON, M.I.C.E., M.I.Mech.E., etc.

The New Course will

commence on September 10th. New students enter at the School on the morning of September 9th. Prospectus, etc., of the PRINCIPAL. X 862

UNIVERSITY OF MANCHESTER.
DEPARTMENT OF ELECTRICAL ENGINEERING.

Departments of Civil,

Mechanical and Electrical Engineering.
Full particulars of these courses will be forwarded on application to the registrar.
The Session commences on the 8th October. X 912

The Royal Technical College,

GLASGOW.

SESSION 1919-19.
BEGINS ON SEPTEMBER 24TH.

The DIPLOMA of the COLLEGE is granted in the following Departments — Civil Engineering, Mechanical Engineering, Electrical Engineering, Mining, Naval Architecture Chemistry, Metallurgy, Building, Textile Manufacture, Dyeing and Sugar Manufacture.
The Diploma Courses extend over either three or four sessions, and the fee per session is £15 15s.
The College is affiliated to the University of Glasgow, and the degrees of the University in Engineering and Applied Chemistry are open to its students.
Prospectuses (free) will be sent on application to the Director. X 853

I.C.E. Correspondence

COACHING. 15 years' continuous success. New papers "Engineering Drawings, Specns. and Quantities" now ready.—7434, Offices of ENGINEERING.

Correspondence Tuition.—

B.Sc., Inst. C.E., Inst. M.E.; also Single Subjects by Honours B.Sc., A.M.I.C.E., etc. Fees moderate.—Address, 7879, Offices of ENGINEERING.

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 7882

A.M.I.C.E. and A.M.I.M.E.

Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—PENNINGTONS, 264, Oxford Road, Manchester.

TENDERS.

URBAN DISTRICT COUNCIL OF
NEWTON-IN-MAKERFIELD.

The above named Council Invite

Tenders for Overhauling Two

BOREHOLE PUMPS at their Water Works, Newton-le-Willows.
The work consists in drawing the pumps, renewing the pipes and refitting. Particulars can be obtained from Mr. R. T. SURTEES, M.I.Mech.E., Gas and Water Engineer, The New Gas Works, Earlestown, who will make arrangements to show intending contractors the work.
Sealed endorsed tenders to be delivered to the undersigned on or before September 1st.

By Order.
CORNELIUS COLM,
Clerk to the Council.
Town Hall, Earlestown. X 849

THE NOTTINGHAM COLWICK ESTATES
LIGHT RAILWAY CO.

The Directors Invite

Tenders for the Supply of the

following stores:
1. (a) Flat-bottomed Railway Rails, weighing not less than 75 lbs. per yard; Fishplates; Fishbolts; Soleplates and Spikes. To be in accordance with the respective British Standard Specification.
(b) Sleepers, Baltic Red Wood or equivalent; impregnated with creosote.
(c) Sleepers, Reinforced Concrete.
2. The above mentioned in paragraph (a) in good serviceable second-hand condition suitable for use in Second-class Running Roads and Sidings.

The Directors do not bind themselves to accept the lowest or any tender.
Specifications and tenders to be addressed to:
The ENGINEER,
Nottingham Colwick Estates Light Rly. Co.,
Trent Navigation Bldgs.,
Wilford Street,
Nottingham. X 881

CITY OF SHEFFIELD.

ELECTRIC SUPPLY DEPARTMENT.

For Sale:—

Two BOILERS, SUPERHEATERS and AIR HEATERS being dismantled at the Neepsend Generating Station.
These boilers are of the 5 drum type, list size 12.W, manufactured by the Stirling Boiler Co., Ltd., suitable for a working pressure of 200 lbs. per square inch, and are capable of evaporating 30,000 lbs. per hour.
The drums are 18 ft. 4in. long, and the frontage of the boiler when erected is 19 ft. 7 in.
Each boiler is fitted with 7/8 in. dead weight safety valves, 3 in. gunmetal feed regulating and check valves, water gauge, and all the usual fittings, also ladders, platform, etc.
The Stokers are of the Class H Underfeed type, fitted with forced draught, and were installed in 1915.
The motors and induced draught fans are not included in the sale.
These boilers are being dismantled by the Stirling Boiler Co., Ltd., and the whole of the materials, except some of the boiler tubes, which are not included in the sale, will be stored at the Neepsend Generating Station, where it may be inspected at any time by appointment during the ordinary working hours of the department.
Tenders to be delivered to Commercial Street, Sheffield, not later than first post on Monday, September 1st.
The highest or any Tender will not necessarily be accepted.
Envelopes to be marked "Tender for Boilers."

S. B. FEDDEN,
General Manager and Engineer.
Commercial Street,
Sheffield,
16th August, 1919. X 880

Tenders Invited for Large

Quantities of Drop Forgings for ship and motor car work. Applications to TENDERS, WM. PORTEOUS & Co., Advertising Agents, Glasgow. X 823

LONDON COUNTY COUNCIL.

The London County Council invites

Quotations for the Supply to

the London Fire Brigade, for use by the London Ambulance Service, of 4, 8, and 12 MOTOR CHASSIS for Ambulances. An outline specification and other particulars, can be obtained by written application to the CHIEF OFFICER, London Fire Brigade, Headquarters, Southwark, S.E. 1.

JAMES BIRD,
Clerk of the London County Council.
X 941

THE SECRETARY OF STATE FOR INDIA
IN COUNCIL
is prepared to receive,

Tenders from such

persons as may be willing to supply AXLEBOXES.
The Conditions of Contract may be obtained on application to the DIRECTOR-GENERAL of STORES, India Office, Whitehall, S.W., and Tenders are to be delivered at that office by Two o'clock p.m. on Tuesday, the 16th September, 1919, after which time no Tender will be received.

G. H. COLLIER,
Director-General of Stores.
X 834

G. R.

By arrangement with the Disposal Board, the Admiralty has

For Disposal a Number of

DIESEL ENGINES (Krupp, Korting, M.A.N., &c.) ex-German Submarines, which should be valuable to commercial power users, etc. These engines are lying at Swansea, Blyth, Derwenthaugh, and London, and may be inspected on presentation of Tender form, obtainable on application to the DIRECTOR OF CONTRACTS (Branch 2a), Admiralty, London, S.W. 1. X 961

G. R.

MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSAL BOARD,

For Sale, by Public Tender,

SEMI-DIESEL MARINE ENGINES with the usual accessories, tools and spare parts, but no propellers or shafting.
2-sets 120 B.H.P. hot bulb, two-cylinder engines, direct reverse. Makers: Ruston & Hornsby.
4-sets 80 B.H.P. as above.
2-sets 90 B.H.P. two-cylinder Kromhout engines, Clutch reverse. Makers: Messrs. Plenty.
3-sets 76 B.H.P. two-cylinder engines with air reverse. Makers: Messrs. Petters.
2-sets 55 B.H.P. three-cylinder "Nat" engine. Makers: Torbinic Engineering Co.

Tenders close 10 a.m., 10th September, 1919. For Tender forms and permits to view, apply to the CONTROLLER, D.B 1 (e), Charing Cross Embankment Buildings, London, W.C. 2.
NOTE.—For *Surplus*, the detailed list of Surplus Government Property for Sale, apply at the nearest Bookstall, or to a local newsagent (to whom a standing order should be given). Compiled by the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. Price 3d. X 836

G. R.

MINISTRY OF MUNITIONS OF WAR.
BY DIRECTION OF THE DISPOSAL BOARD.

For Sale by Public Tender.

CONTRACTORS—ENGINEERING PLANT.

STEAM NAVVY, Standard rail gauge. Crab Bucket 2½ yd. cu. capacity, by Dumbar & Rushton. Ref. M.K. 7289. Lying at H.M.O.W. Gravel Pit, Taplow.
ONE 5 TON Steam Travelling Crane, standard gauge, 25-0 jib. Ref. M.K. 7295. Lying at Aldeburgh Aerodrome, Aldeburgh. One ditto 75-0 jib by Rushworth Bros. Lying at Orfordness Aerodrome, Suffolk.
WINGET BLOCK MAKING MACHINES, with large quantities of cones, pellets and spares.
Winget Mixer, complete with paraffin engine mounted on wheels suitable for a 2-0 gauge. Steam rock drill, complete with boiler and piping. Green's patent hand motor roller. Pile barge, complete with frame boiler, winch, monkey, etc. Planer and thicknessing machine, 13 by 7, with patent roller feed chain gear for 3 speeds, adjustable table and countersbafting. Above lying at Calshot Seaplane Station, Air Ministry, Calshot.
THREE DISINTEGRATOR MACHINES, by Christy & Norris, fitted with all the latest improvements, including special set of iron, steel-faced beaters, complete with strong wood guiding stand and sides with dust-tight door. Lying at Chatham, Portsmouth and Devonport.
PORTABLE CRANE, mounted on four strong block wheels, jib 9-0 high to lift 1½ tons, complete with hand winch. Ref. M.K. 6884. Lying at Farnborough.
HAMMERHEAD ELECTRIC CRANES, base 6 ft. by 5-3 high, mounted on 4 flange 1 wheels, inside flange measurement 3 ft. 3½ in. Approx. height of jib 61 ft., swing of jib 13 ft., load 6 cwt. Complete with controller and two motors, chain, jib, rope balance block and winding drum suitable for 440 volt, D.C. Ref. M.K. 6955 to 6964. Above lying at Stores No. 40, West Float, Birkenhead.
Tenders for any of the above must be submitted by 10 a.m., September 5th.
Fuller particulars together with tender forms and permits to view can be obtained on application to the CONTROLLER, D.B.1.(e)., Charing Cross Embankment Buildings, London, W.C.2.
NOTE.—For *Surplus*, the Detailed List of Surplus Government Property for Sale apply at the nearest Bookstall or to the Director of Publicity, Ministry of Munitions, Whitehall Place, S.W. 1, price 3d. X 751

INDIA OFFICE, WHITEHALL,
22 August, 1919.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL is prepared to receive

Tenders from such

persons as may be willing to supply:—
(1) MILD STEEL PLATES.
(2) MILD STEEL SHEELS.
(3) MILD STEEL PLATES AND SHEETS GALVANIZED.

The Conditions of Contract may be obtained on application to the Director-General of Stores, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that Office by Two o'clock p.m. on Tuesday, the 9th September, 1919, after which time no Tender will be received.

G. H. COLLIER,
Director-General of Stores.
X 920

G. R.

SALE OF ELECTRICAL PLANT AT THE POST OFFICE SAVINGS BANK, LONDON,
AND AT THE
HEAD POST OFFICE, MANCHESTER.

BY ARRANGEMENT WITH THE DISPOSAL BOARD.

Tenders are Invited for the

PURCHASE & REMOVAL of a SECONDARY BELL BATTERY from the Generating Station at the Post Office Savings Bank, West Kensington, W. 14, and for the PURCHASE and REMOVAL of a SECONDARY BATTERY and MISCELLANEOUS SWITCH-GEAR from the Sub-Station at the Head Post Office, Manchester. Specifications containing full particulars and forms of tender may be obtained on application to the Controller, Post Office Stores Department, Studd Street, Islington, N. 1.
Tenders will be received up to 10 a.m. on Friday the 29th August, 1919.
General Post Office, August, 1919. X 934

BOMBAY, BARODA & CENTRAL INDIA
RAILWAY COMPANY.

The Directors are prepared to receive, up to Noon on Friday, 5th September,

Tenders for the Supply of:—

1. TRANSVERSE STEEL SLEEPERS and KEYS.
2. DOG SPIKES.

Tenders must be made on forms, copies of which, with specification, can be obtained at these Offices, on payment of 20s. each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.
Offices: 110, Bishopsgate, London, E.C. 2.
20th August, 1919. X 944

THE GREAT INDIAN PENINSULA RAILWAY
COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

	Specification Fees
1.—Station Bells, Bib Cocks, etc.	7s. 6d.
2.—Dressed Wagon Covers	£1 0 0
3.—Plate Glass, etc.	10s. 0d.
4.—Galvanised Stamped Steel Mortar Pans	5s. 0d.
5.—Leather Hides, etc.	10s. 0d.
6.—White Lead	£1 0 0

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.
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JAMES WATT.*

By Engineer-Commander EDGAR C. SMITH, R.N.

"NOT to perpetuate a name which must endure while the peaceful arts flourish, but to show that mankind have learned to honour those who best deserve their gratitude, the King, his ministers, and many of the nobles and commoners of the realm, raised this monument to James Watt, who directing the force of an original genius, early exercised in philosophic research, to the improvement of the steam engine, enlarged the resources of his country, increased the power of man, and rose to an eminent place among the illustrious followers of science, and the real benefactors of the world."

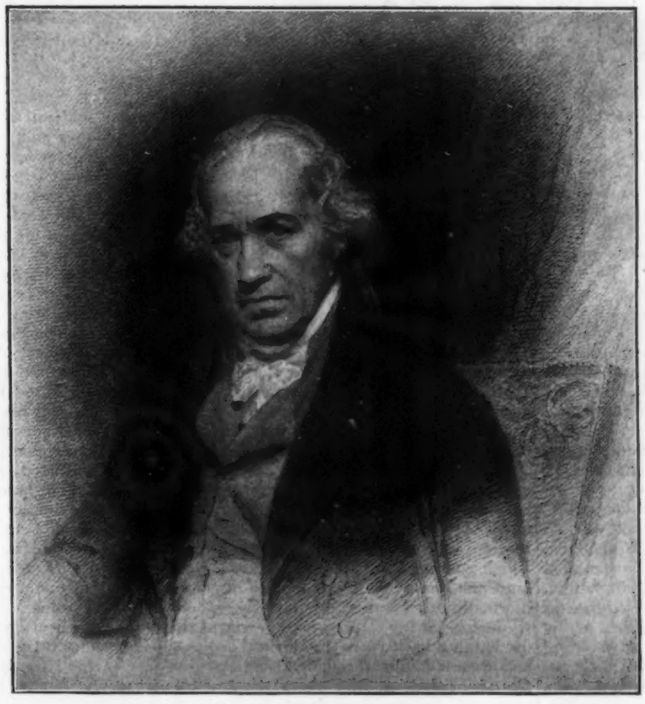
So runs Brougham's famous epitaph on Chantrey's colossal statue of Watt in Westminster Abbey. Alike remarkable in its inception and execution and in its incongruity with its surroundings, Chantrey's statue has not been without its critics, but in all its history there never has been a question as to the truthfulness of the inscription the composition of which Brougham regarded as one of the honours of his life. Thrust into position with the greatest difficulty, as if it were reluctant to intrude among the reposing courtiers of a bygone age, the statue dominates the little chapel of St. Paul. Around it are the memorials to the bearer of King Henry's standard at Agincourt, the president of the court which tried Mary, Queen of Scots, and the lady founder of a Cambridge college. These are, however, dwarfed by Chantrey's massive work which so strangely finds a resting place where once was preserved the sacred cloth in which was wrapped the head of the martyred St. Paul. Without the chapel are the tombs of kings and queens, while but a little to the east one enters the chapel of Henry the Seventh, that marvel of craftsmanship where "stone seems by the cunning labour of the chisel, to have been robbed of its weight and density, suspended aloft as if by magic and the fretted roof achieved with the wonderful minuteness and airy security of a cobweb."

Only two engineers are buried in the Abbey, Telford and Stephenson, who lie side by side, in the nave, and Telford is the only engineer beside Watt honoured with a statue. There are windows in the north aisle to Locke, Trevethick, Stephenson, Brunel, Baker, Siemens and Kelvin, but the memorials to men of science and to engineers by no means fully represent the important part these have played in the progress of the nation. England, perhaps not without reason, has been reproached that she often fails to recognise the merits of her scientific men. It is true that she can show nothing so worthy as the fine memorial erected fifty years ago to Galileo at Florence. It is true that the places of Newton and Harvey, of Davy and Jenner, of Watt and Stephenson, on the Albert Memorial are usurped by Spanish painters and German musicians, and it is likewise true there was hesitation in according space in Westminster Abbey for a small tablet to Joule. On the other hand, many memorials to men of science have been erected, and Watt is commemorated perhaps more than any of his fellows.

The eulogies passed upon Watt have been innumerable, and Brougham was but one who stirred his hearers with his sounding periods. In his retirement Watt won a whole host of golden opinions.

"And that which should accompany old age,
As honour, love, obedience, troop of friends,"

he possessed to the full. At the meeting in June, 1824, at the Freemason's Tavern in Great Queen-street, which led to the erection of the statue in the Abbey, the Prime Minister (Lord Liverpool) presided and Brougham, Mackintosh, Peel, Huskisson and Wilberfore were all present. It was on this occasion Davy compared Watt to Archimedes. Watt had then only been dead five years, but long after this Wordsworth said "I look upon him considering both the magnitude and universality of his genius as perhaps the most remarkable man this country has produced." Arago's *éloge* to the Paris Academy of Sciences was scarcely less eulogistic, while another Frenchman wrote that the part Watt played in the mechanical application of steam can only be compared to that of Newton in astronomy and Shakespeare in poetry. Watt was in the full sense of the term one of Emerson's "Representative Men."



From the original picture by Sir William Beechey, R.A.

JAMES WATT.

For the details of Watt's life we are mainly indebted to Muirhead and to Smiles, whose biographies appeared in 1858 and 1865 respectively. Arago's "Éloge" was pronounced in 1835, and the account of Watt in the Dictionary of National Biography was from the pen of Sir Frederick Bramwell. Among the later and smaller biographies may be mentioned that of Mr. Andrew Carnegie, who speaks of Watt as "one of the finest characters that ever graced the earth," while among the latest additions to Watt literature is Mr. H. W. Dickinson's paper contributed in 1915 to the Institution of Mechanical Engineers, and entitled "Some Unpublished Letters of James Watt."

Watt was born at Greenock, January 19, 1736, and died at Heathfield, August 19, 1819, at the age of 83. His father, also James Watt, died in 1782, at the age of 84, while his grandfather, Thomas Watt, born in 1642, died in 1734. The lives of father, son and grandson thus cover the extraordinary period of 177 years. A magistrate and elder, Thomas Watt is described on his tombstone as a "Professor of the Mathematics." Of his six children but two reached manhood: John, who settled in Glasgow as a surveyor and died a bachelor in 1737, and James, born 1699, who became a shipwright, builder and merchant, and occupied a prominent place among the worthies of old Greenock. James and his wife, Agnes Muirhead, had five children, of whom the three eldest died young, the fourth became the great engineer, and the youngest, John, born in 1739, perished at sea in 1762. Galton, in his work on Heredity Genius, after reviewing the ancestry of men of science, says it "appears to be very important to success in science that a man should have an able mother," and he continues, "it is, I believe owing to the favourable conditions of their early training that an unusually large proportion of the sons of the most gifted men of science become distinguished in the same career." All accounts agree that Watt's mother was a woman of superior character and ability, that Watt's childhood was singularly free from harsh restrictions or narrowness, and that the atmosphere of the home was eminently favourable for the development of the genius he undoubtedly inherited. Most of the incidents of Watt's boyhood come to us from "Some Memoranda of the Early Years of Mr. Watt, by his Cousin, Mrs. Marion Campbell." This Mrs. Campbell, or Marion Muirhead, was one of Watt's companions, and in 1798 she dictated her recollections to her daughter. To her is due the well-known story of Watt at the age of six drawing geometrical figures on the hearth, and also the story of his holding a cup and a spoon over the steam issuing from the kettle. It was to her Watt said that before he was 15 he had twice read s'Gravesande's "Elements of Natural Philosophy." As this work had a profound influence on Watt, it may not be out of place to trace its history. s'Gravesande's was a professor of mathematics at Leyden who, as a young man of 27, came to London as secretary to the Dutch Mission sent to congratulate George I on his accession. During his visit he became known to Newton, was admitted F.R.S. and gained a knowledge of the Newtonian philosophy. After his return to Holland he published in 1720 his "Physices Elementa Mathematica." At the time of his visit to London the demonstrator to the Royal Society was John Desaguliers, the son of a French protestant minister who had fled to England on the Revocation of the

* Next month there will be held the Centenary Commemoration of the death of James Watt, and we are glad to find that there is every prospect of the occasion being honoured as it deserves to be. In the City of Birmingham, with which Watt was so intimately connected, the matter has been taken up in a most thorough way, and the proceedings there will extend over three days, namely: September 16th, 17th and 18th. Action is also being taken at Greenock, and at South Kensington a special exhibition of Watt's relics is being arranged. With these various functions we shall deal in due course, but meanwhile we place before our readers a short memoir which we trust will be read with interest.

Edict of Nantes. Desaguliers, then about 32, was the Tyndall—or perhaps more correctly the Lardner—of his day, and it was his translation of s'Gravesande's work Watt read. Later on, Watt studied Desaguliers's own works on Mechanical and Experimental Philosophy, which contain a good deal of what is now known of the Newcomen steam engine. Desaguliers was not only a writer, but he made improvements in machinery and gained a wide reputation by the courses of lectures which he delivered first at Oxford, then in Westminster and then at the old Bedford Coffee House which stood not very far from the site of the present offices of ENGINEERING. He died in 1744, and was buried in the Savoy. His name is connected with no great discovery, but he played a leading part in the spread of a knowledge of Newton's discoveries, and it is a curious reflection that Watt should have gained his first insight into the work of Newton through a Frenchman's translation of a latin work written by a Dutchman who came to see a German king ascend the throne of England. In later years Watt was also much indebted to the "Architecture Hydraulique" of the French engineer Belidor (1693–1761), while on his return from London in 1756 among his luggage was a copy of Stone's translation of the "Traite de la Construction et des Principaux usages des Instruments de Mathematiques" of Nicolas Bion (1652–1733).

Though frequently laid aside by ill-health, Watt as a boy attended M'Adam's Commercial School and the Greenock Grammar School, but he owed less than most men to his schoolmasters. At home he read and experimented incessantly, and in his father's workshop he early displayed that mechanical skill for which he was noted, and which caused his father's workmen to say: "Jamie has a fortune at his fingers ends."

Watt having attained the age of 18, it became necessary for him to choose a calling, and so, in 1754, he went to Glasgow, and began work with the idea of becoming a mathematical instrument maker. His master, however, proved quite incapable of giving his apt pupil suitable instruction, and it was decided Watt should go to London. Provided with a letter of introduction from Dr. Dick, Professor of Natural Philosophy at Glasgow, to James Short, the astronomer and optician, and accompanied by his relation, Captain Marr, he set out on horseback on June 5, 1755, and arrived in London twelve days later. After considerable difficulty he secured a bench in the shop of John Morgan, in Finch-lane, Cornhill, where he was to receive a year's instruction for a premium of 20*l*. Smeaton, ten years before, had been similarly initiated into the mysteries of London's workshops, and had had a business of his own in Holborn. Exercising a frugality rivalling that of Nasmyth when at Maudslay's, Watt lived on 8*s*. a week, and by sticking very closely to his work he quickly gained the experience he sought, and in a short time was constructing a Hadley's sextant. Though John Hadley and "honest George Graham," were both dead, London at this time possessed a most remarkable group of mechanicians. There were John Bird and James Short, Dolland, Harrison, Arnold, Mudge, Adams and Coventry, while the noted Ramsden had come to London about the same time as Watt. It is perhaps worth noting that the improvements made during the eighteenth century in clocks and watches and instruments—quite as remarkable as the improvements in the mechanics of machinery—were largely due to an Act of Parliament, the Longitude Bill of 1713, and it is possible, had similar action been taken in regard to the steam engine and the cotton and iron industries the work of Watt and Arkwright and Cort might well have been advanced by a quarter of a century or more.

Watt's stay in London lasted just a year. He seems to have done remarkably little sight-seeing, and took but two holidays, one of these being the day we declared war on France. The London of his day was a vastly different place from what we know, and little could he have dreamt he was to be one of the foremost in bringing about the great changes in city life which the nineteenth century saw. In 1755 the city walls still stood; the city gates were still closed at sunset. Badly paved, ill-lighted, with few exceptions uncleansed, the noisy streets were filled with a multitude of hawkers crying their wares. Thieves, pickpockets and crimps abounded. To venture abroad at night needed not a little courage, and Watt, not being a freeman, stood in deadly fear of the press gang. The stocks, the pillory and the gibbet were all in use, while London's amusements included the delights of Vauxhall Gardens, the prize ring, bull and bear baiting and cock-fighting. Hard drinking was the order of the day, and Besant tells us that every sixth house was a gin shop. Close by Morgan's premises stood the Bank, then a small affair, hidden behind taverns and houses and the church of Christopher-le-Stocks, long since gone. In a direct line with Finch Lane was Birchin Lane, where according to *The London Gazette* of August 14, 1716, every Wednesday at the Sword Blade Coffee House information could be obtained regarding "the invention for raising water by the impellant force of steam, authorised by Parliament, so lately brought to the greatest perfection . . . as is sufficiently demonstrated by diverse engines of this invention now at work in the several counties of Stafford, Warwick, Cornwall and Flint." Not very far away from Cornhill stood the old London Bridge, the houses still upon it, and in the three arches at the north end, were the water wheels and pumps which supplied water to the city. The wheels were worked by the flow and ebb of the tide, and the device for raising and lowering the wheels was the invention of Hadley, of sextant fame. Steam engines had been at work in London long before Watt's time. Savery, whose workshops had been in Salisbury Court, Fleet Street, and who died in Westminster, had shown his model to the Royal Society in 1699, and erected one at a potters in Lambeth, where, by the force of water he nearly blew off the tiles of the house. Newcomen had also seen much of London, and though not generally known he lies buried in the Bunhill Fields, where are the graves of Bunyan and Defoe. There was a Newcomen engine at Campden House, Kensington, while a still more famous one was to be seen at York Buildings, near the Charing Cross end of the Strand. "There you see," so ran the "Foreigner's Guide" for 1720, "a high wooden tower and a water engine of a new invention, that draws out of the Thames about 3 tons of water in 1 minute by means of the steam arising from water boiling in a great copper, a continual fire being kept to that purpose; the steam being compressed and condensed, moves by its evaporation, and strikes a counterpoise, which counterpoise strikes another, at last moves a great beam, which by its motion of going up and down, draws the water from the river, which mounts through great iron pipes to the height of the tower, discharging itself there into a deep leaden cistern; and thence falling through other large iron pipes, fills them that are laid about the streets, and so continuing to run through wooden pipes as far as Mar-bone Fields, falls there into a large pond or reservoir, from whence the new buildings near Hanover Square, and many thousand houses, are supplied with water. This machine is certainly a great curiosity; and though it is not so large as that of Marly, in France, yet, considering its smallness in comparison with that, and the little charge it was built and is kept with, and the quantity of water it draws, its use and benefit is much beyond that."

The machine at Marly referred to was long the wonder of Europe. Desaguliers spent a week sketching and examining it, and when Boulton and Watt went to France in 1786 it was principally to advise the French Government as to its improvement. With its 14 water wheels and something like 250 pumps, this "gigantic specimen of a race of mechanical megalo saurians," as Muirhead calls it, was the most extensive and probably the least efficient machine ever erected. It was, we believe, finally replaced by a Watt engine, but at what date we do not know. The steam pump of the first half of the eighteenth century was that described in the "Foreigners' Guide," and it received few improvements till Smeaton and then Watt began their inquiries. Watt was afterwards to supply many steam engines to London, and one of these, made in 1797 for John Maud, chemist, of 66, Aldersgate-street, E.C., now stands entire in South Kensington Museum. (See Fig. 1). Watt's stay in London came to an end in August, 1756. He had long been out of health, and with his father's consent he returned to Greenock.

Watt had now reached manhood. Determined to strike out for himself he went to Glasgow to set up as a mathematical instrument maker. Again he met with difficulty, but friends came to the rescue, and in spite of the Corporation and the Guild of Hammermen, he was able to begin work in the old Glasgow College. Fairly launched on the highway of life he earned a living, established a reputation, and became known to Adam Smith, Simson the great Euclidean scholar, John Anderson the founder of the Andersonian Institute, Joseph Black and John Robison. Black was not yet thirty; Robison still under twenty. Watt's friendships deserve a volume to themselves. When Watt was not making sextants he studied chemistry. From mending fiddles and guitars he proceeded to build organs. All his leisure was given to reading and experimenting. His room in the college became a favourite meeting-place, and the young instrument maker a man to be consulted. By 1760, Watt had moved to a shop in the Saltmarket, and in one—John Craig—had found a partner. Three years later the Glasgow Journal announced the removal of the business to "Mr. Buchanan's land in the Trongate," where were sold "all sorts of mathematical and musical instruments, with variety of toys and other goods." In 1764 the partners had no fewer than 16 employees, and the prosperous Watt left the College altogether, in July married his cousin, Margaret Miller, and set up house in Delft-field Lane. Six or eight months' later he made his great discovery of the separate condenser.

How Watt was led to this discovery we know from his own words. When nearly 80 years of age, he wrote an account of his experiments. This interesting narrative, first published in the "Encyclopaedia Britannica," appeared in Robison's "System of Mechanical Philosophy," published by Brewster in 1822, and it is reproduced in full in Sir Alfred Ewing's work on "The Steam Engine." He says his attention was called to the steam engine by Robison in 1759. In 1761 and 1762 he began experimenting in earnest. To a Papin's digester he affixed a small cylinder and piston, but apparently did not proceed very far. Belonging to the Natural Philosophy Class was a model of a Newcomen engine. It had been sent to Sisson, of London, for repairs, and in the winter of 1763–64 came into Watt's hands. Setting it to work he obtained but indifferent results. It suffered from shortage of steam. This at once started Watt on a train of scientific inquiries, the first research ever carried out on the steam engine. All his knowledge up to this time had been derived from Desaguliers, from Belidor and from Switzer (1682–1745), who was a kind of scientific gardener; but these gave him little guidance. He studied the expenditure of fuel in evaporating, experimented on condensation and on the relations between the temperature, pressure and volume of steam. By means of a kettle, a bent glass tube and a vessel of well water, he was led to see that: "Water converted into steam can heat about six times its own weight of well water to 212 deg., or till it can condense no more steam. Being struck with this remarkable fact and not understanding the reason of it, I mentioned it to my friend Dr. Black, who then explained to me the doctrine of latent heat, which he had taught for some time before this period (summer, 1764), but having myself been occupied with the pursuits of business, if I had heard it I had not attended to it, when I thus stumbled upon one of the most material facts by which that beautiful theory is supported." From his experiments, Watt concluded that to make the best use of the steam the cylinder should be kept as hot as the steam which entered it and that this steam and the condensed water should be cooled down to 100 deg. or lower, but the means of accomplishing this were not at first evident. The flash of inspiration came one Sunday early in 1765:

"I had gone to take a walk, on a fine Sabbath afternoon early in 1765. I had entered the Green by the gate at the foot of Charlotte-street, and had passed the old washing-house. I was thinking upon the engine at the time, and had gone as far as

the herd's house, when the idea came into my mind that as steam was an elastic body it would rush into a vacuum and if a communication were made between the cylinder and an exhausted vessel it would rush into it, and might there be condensed The second was to make the pump large enough to extract both water and air. . . . I had not walked," he continues, "further than the golf-house when the whole thing was arranged within my mind."

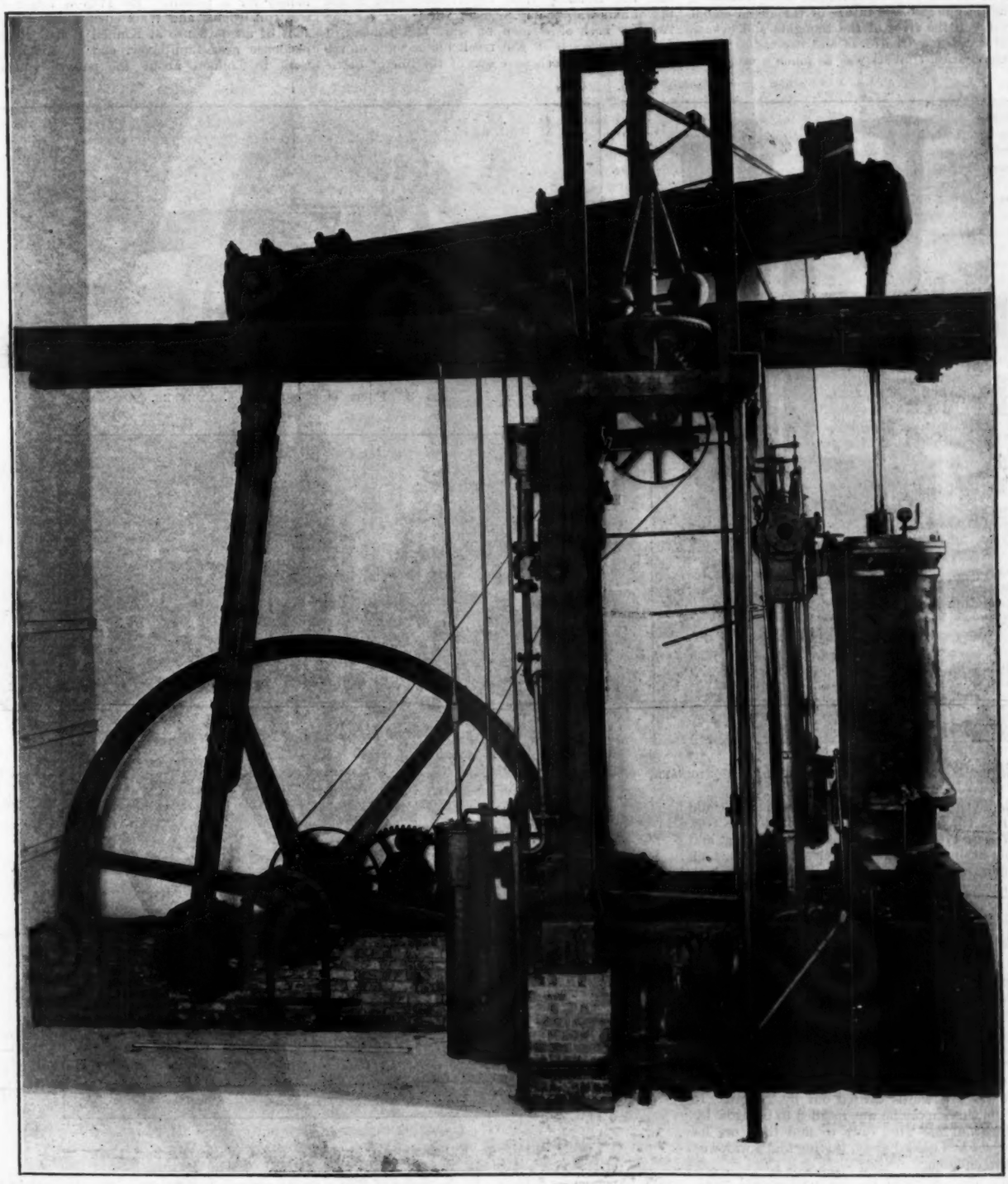


FIG. 1. "SUN AND PLANET" ENGINE SUPPLIED IN 1797 TO JOHN MAUD, 66, ALDERSGATE-STREET, LONDON

without cooling the cylinder, I then saw that I must get rid of the condensed steam and injection water if I used a jet as in Newcomen's engine. Two ways of doing this occurred to me. First the water might be run off by a descending pipe, if an off-let could be got at a depth of 35 ft. or 36 ft., and any air might be extracted by a small pump.

It is not too much to say that this discovery changed the course of Watt's life. During the previous nine years he must often have been in the position of Maury who, when deemed unfit for sea service, wrote "I'll content myself with cultivating a few patches of knowledge. What shall they be? Shall they be light or heat, storms or currents, shipbuilding or ship sailing? Steam or projectiles? Hollow shot or gravitation? Gases or fluids, winds or tides? Or?" The patches of knowledge Maury cultivated led him to become the sailor's guide and the foremost meteorologist of his day, while the patches Watt cultivated gave the world the modern steam engine and made Watt the father of mechanical engineering. From henceforth the steam engine absorbed him. "My whole thoughts are bent on the machine, I can think of nothing else."

During the succeeding nine years, that is from

1765 to 1774, from this discovery of the separate condenser till his removal to Birmingham, Watt, as it were, led a double life. We see him playing two parts. On the one hand we see him as the capable, respected citizen, providing none too easily for the needs of his growing family, and on the other hand we see him as the only human being possessing a true insight into the future of the steam engine carried "in the river of the thoughts and events, forced onward by the ideas and necessities of his contemporaries." Watt was as much a bondslave preserved as carefully as Newton's telescope and Davy's safety lamp at the Royal Society. With this interesting relic is also his first tube surface condenser fitted with 140 tiny tubes (see Fig. 3). A thing that can be slipped into one's coat pocket, this is the first of all such condensers, and the troubles Watt experienced with it are not unknown to-day. The condenser is the Achilles heel of a man of war, and readers of Lord Jellicoe's book will recall his account of the various ships which were out of the line of battle

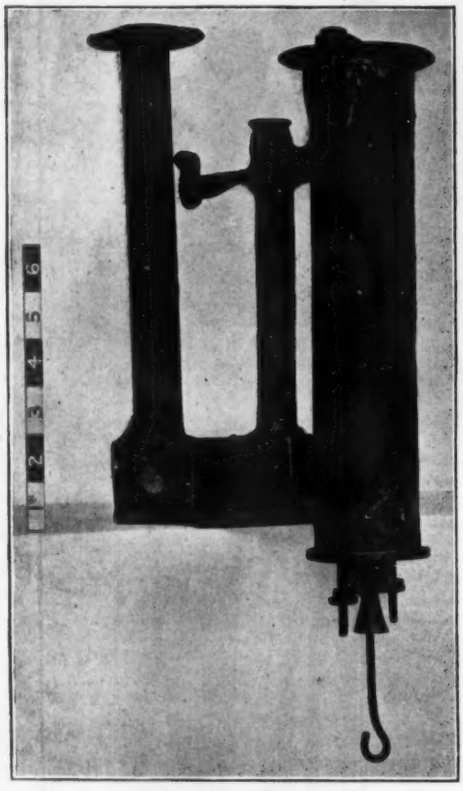


FIG. 2. ORIGINAL CYLINDER AND PLATE CONDENSER.

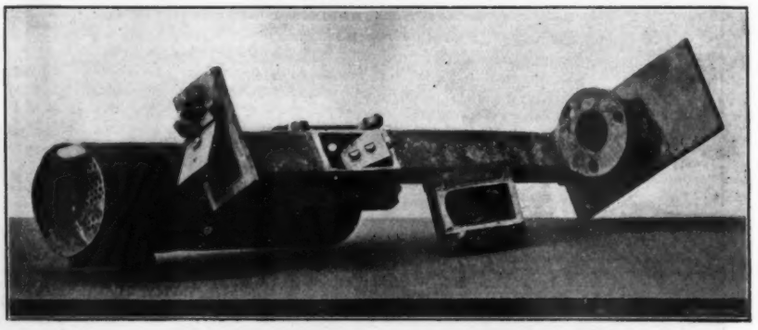


FIG. 3. FIRST TUBE SURFACE CONDENSER.

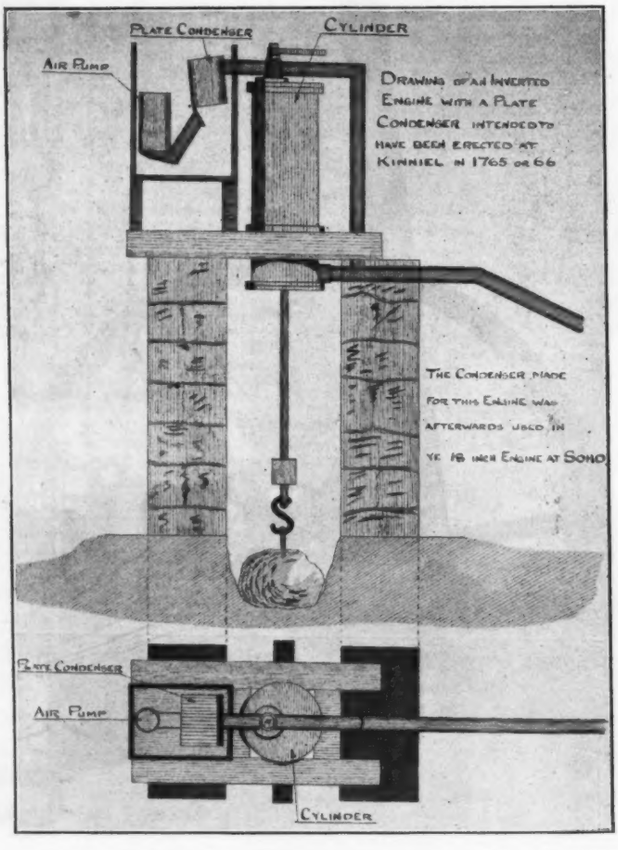


PLATE CONDENSER
CYLINDER
AIR PUMP
DRAWING OF AN INVERTED ENGINE WITH A PLATE CONDENSER INTENDED TO HAVE BEEN ERECTED AT KINNIEL IN 1765 OR 66
THE CONDENSER MADE FOR THIS ENGINE WAS AFTERWARDS USED IN YE 18 INCH ENGINE AT SOHO
PLATE CONDENSER
AIR PUMP
CYLINDER

FIG. 4. EXPERIMENTAL ENGINE: FROM WATTS PATENT, 1769.

to his inventive faculty as was Ericsson and could not rest till his ideas had been put to the test. In 1765 or 1766, Watt lost his partner, Craig, and finding business falling-off, he closed his shop, took an office, and turned surveyor. He thus undertook the survey of the Forth and Clyde Canal, *via* Loch Lomond, a project which took him to London in 1767. In 1769 he surveyed a coal canal from Monkland to Glasgow, and for two years and a half, at a salary of 200*l.*, acted as engineer of it. In 1770 he surveyed the Strathmore Canal, receiving 80*l.* for forty-three days' work, and the same year designed a bridge for Hamilton for a fee of seven guineas. He drew up plans for docks at Port Glasgow and for a harbour at Ayr, and also superintended the erection of some Newcomen engines. In 1773 his career as a civil engineer came to an end with the survey of the Caledonian Canal, a project which was afterwards carried out by Telford. It was from this survey he was recalled to Glasgow by the illness of his wife, only to find that ere he arrived she had passed away, leaving him a widower with two children.

While thus engaged on his professional work Watt's fertile brain had been busy with a hundred matters, ranging from micrometers and the determination of the moon's parallax to the manufacture of pottery. But the new "fire engine" was never far from his thoughts. Immediately after his Sunday afternoon walk he began experimenting again. To a brass syringe for cylinder, he affixed a little plate condenser. One piece of his original apparatus is at South Kensington (see Fig. 2), owing to condenser defects. In the spring of 1765, Watt hired a cellar and proceeded to build a model engine; in August he removed to a disused pottery and made another engine with a hammered cylinder of 5 in. or 6 in. diameter. Black, who had been lending him money to prosecute these experiments, now introduced him to Roebuck, the founder of the famous Carron Iron Works, and by November, 1765, Watt was able to send Roebuck detailed drawings of a cylinder and piston to be made at the works. A sketch of one of his early experimental engines included in the specification of his patent of 1769 is shown in Fig. 4. Though none of these experimental engines had been successful, Roebuck, confident of the soundness of Watt's views, encouraged him, guaranteed his debts, and promised to find money for a patent. By 1768 a larger engine was constructed and Watt erected it in the seclusion of an outhouse at Kinneil House, Roebuck's residence near Linlithgow, and in August Watt went to London about the patent, which was finally secured in 1769. On his way home in 1767 Watt had visited Soho, and in 1768 he did so again, and then for the first time met Boulton. The next four years saw but little advance. The Kinneil engine was completed, but worked badly, and Roebuck became financially involved. In 1770 Watt sent drawings of his engine to Boulton, and from that time, more or less regular intercourse took place, and when Roebuck failed Boulton took over his share of the patent. The preliminary negotiations

between Watt, Roebuck, Small and Boulton form one of the most interesting chapters of Muirhead's biography. In the spring of 1773 the Kinneil engine was dismantled and packed, and in May, 1774, Watt turned his back on instrument-making, surveying and civil engineering, and left Glasgow for Birmingham, where in the words of Smiles "he at once entered on a new and important phase of his professional career."

With his removal to Birmingham in 1774, Watt, then at the age of 38, entered upon his period of greatest activity. All his work on the new "fire engine" up to that time had been in the nature of experiment. He was now happily to see it put to practical use, first as a pumping engine, then as an engine suitable for all purposes. To the capital improvements of the condenser and the air pump he was to add those of double-acting and expansive working and to combine with them devices for obtaining rotary motion with means of regulating the motion of the engine, lessening its consumption

FIG. 5. THE SOHO MANUFACTORY NEAR BIRMINGHAM.

and making it more reliable. The actual partnership of Boulton and Watt lasted from 1775 to 1800, but it was the first ten years that saw Watt's most brilliant work. This was the period in which, to use Sir Richard Gregory's words, "Watt transformed a rude and imperfect steam engine into an efficient and powerful working instrument, and by so doing accomplished the greatest work performed by any engineer of modern times." In all he undertook he was more than ably seconded by Boulton, and whatever success he achieved was largely due to Boulton. The characters of Boulton and Watt have often been sketched, and Smiles said, "had Watt searched Europe through, probably he could not have found a man better fitted than Matthew Boulton for bringing his invention fairly before the world." Boulton was the Wedgwood of the metal trade, and his famous Soho manufactory (Fig. 5) attracted many distinguished men to Birmingham, Boulton entertaining them royally at his house, "l'hôtel de la amitié sur Handsworth Heath," as he termed it.

Among the first results of their co-operation was the removal of the Kinneil engine to Soho, where, during 1774–76 it was the subject of many experiments and improvements. Christened by Watt "Beelzebub" this rough, untutored parent of modern steam engines was set to work to feed the water wheel which drove Boulton's rolling mill. This combination of pumping engine and water wheel was the standard arrangement for many years. It becoming known Boulton had taken up the new fire engine, miners and manufacturers began to make inquiries, and the patent of 1769 having but eight years to run, an Act of Parliament was obtained in 1775, extending the patent for twenty-five years. The patent had been "for a new method of lessening the consumption of steam and fuel in fire engines," and the "new method" embraced keeping the cylinder hot by lagging and jacketing, closing the top of the cylinder, using a condenser and air pump and, among other things, using high-pressure steam without a condenser. The first engines made at Soho were supplied, one to John Wilkinson for blowing his bellows at Broseley, Shropshire, and another for the Birmingham Canal Navigation at Smethwick. Both of them were set to work in 1776, and the latter engine continued in use till 1898, when it was removed to Ocker Hill, Tipton, where it will be shown at work under steam during the forthcoming Centenary Celebrations. Of the blowing engine made for John Wilkinson we are able through the courtesy of the British Museum authorities to reproduce in Figs. 6 and 7 the original sketches. The notes on the drawings are annexed to the engravings.

The first engine in the London district was one supplied for Cooke and Company's distillery at Stratford-le-Bow. Early in 1777 Watt went to Cornwall in connection with the famous Chacewater engine. It was during his absence "Beelzebub" was destroyed by fire. Shortly afterwards "Old Bess" was built to replace it, and this engine continued in use at Soho from 1777 to 1848. The cylinder, piston rod, part of the pump barrel, &c., are at South Kensington, where there is a model of the complete engine (see Fig. 8, page 235) which gives a good idea of the Watt engine as supplied for mines. For several years Watt and Boulton found their best market in Cornwall, and the Chacewater engine was looked upon by Watt as the *experimentum crucis*, and many episodes in its history are preserved for us. When working, "the velocity, violence, magnitude and horrible noise of the engine give universal satisfaction to all beholders," wrote Watt. Many a mine adventurer was converted by its performances, with the result that by 1780, of 40 engines built at Soho 20 had gone to Cornwall, and soon after there remained but one Newcomen engine at work in the county.

All this time, Watt, though plagued with headaches, distracted by his workmen, harassed by his clients and often in the deepest despondency, had been overcoming one difficulty after another. In 1781 he obtained a patent "for certain new methods of applying the vibrating or reciprocating motion of steam or fire engines to produce a continuous rotation or circular motion round an axis or centre, and thereby to give motion to the wheels of mills or other machines." He had been forestalled by Pickard in 1780 in the use of the crank, and hence the five devices enumerated in this patent, only one of which—the sun and planet motion—appears to have been used.

This patent of 1781 was succeeded the following year by another "for certain new improvements upon steam or fire engines for raising water and other mechanical purposes and certain new pieces of mechanism applicable to the same" and the specification of this patent included the important features of expansive working, the double-acting engine and the double or compound-cylinder engine. The last of Watt's four steam engine patents was taken out in 1784 "for certain new improvements upon fire or steam engines and upon machines worked or moved by the same." It was in this patent Watt made known his famous parallel motion, which of all his inventions he considered the greatest. Both the engines illustrated in Figs. 1 and 11, will be seen to be fitted with this motion. His improvements to the steam engine were, however, not limited to those covered by the patents. He devised and used the first counter, he fitted pressure and vacuum gauges, he devised the butterfly throttle valve, made metallic packing for pistons, applied the centrifugal governor to the engine and invented the first indicator. His indicator and vacuum gauge are shown in Figs. 9 and 10, page 235. To Watt we are also indebted for the constant 33,000 ft.-lb. as the unit of horse-power. Smeaton's value was 22,916, while Desaguliers used the number 27,500. The term "horse-power" is due to Savery. The first rotary engine built at Soho was erected in 1782, at Ketley, for driving a corn mill. A year or two later they began to be made for the breweries and distilleries of London and among these was the 30-h.p. engine erected at Messrs. Whitbread's brewery, in 1785, which had a life of a century, and after its removal in 1887 was sent to the Sydney Museum. This was the engine, the working of which Watt explained to George III and Queen Charlotte in May, 1787. Most famous of all London engines, however, was the one at the Albion mills, erected in 1786 and destroyed by fire in 1791. What the engine was like at the period can be gauged from the "Lap" engine illustrated in Fig. 11, page 236. Built in 1788, this engine was used for driving the machinery at Soho for lapping or polishing steel ornaments and continued in use till 1858. Three years later it was removed to South Kensington, where, on the opening of the new galleries, no doubt adequate provision will be available for the better display of this and the many other fine historical engines in the Museum.

By the end of the 'eighties the engine business of Boulton and Watt at last began to pay. Beside his engine work, Watt had invented the well-known copying press, constructed a steam-driven tilt hammer, patented a new furnace and devised a steam drying machine; but space does not permit of more than a passing reference to these, or to his assistants Murdock, Southern and others, or to his many friends. Neither is it necessary to dwell on his discovery of the composition of water. The history of science contains few more barren chapters than disputes over priority, and the water controversy is no exception to this. Muirhead devoted three chapters to it, and Sir Edward Thorpe dealt fully with it in 1898 in his Watt Memorial Lecture, which was afterwards published in *Nature*.

Success agreed with Watt, and from about 1790 he took a somewhat less active part in the business of the firm. In 1794 his son and Boulton's son, Robinson Matthew Boulton, were admitted as partners, and maintained for many years the great reputation of the Soho works. The growing tendency to pirate the invention led to the famous trials of Boulton and Watt *v.* Bull, and Boulton and Watt *v.* Hornblower and Maberly. Litigation went on for six or seven years, and some thousands of pounds were spent in costs by Boulton and Watt, in whose favour, however, the verdict was finally given. After this decision the patent had but a year to run, and when this had passed the celebrated partnership came to a close. Watt had already, in 1790, removed to his new house at Heathfield, and there he spent the greater part of the remainder of his life. He had remarried in 1776, and altogether had six children. Of his sons, Gregory, a youth of great promise died in 1804, at the age of 27, while James, born February 2, 1769, the year of the great patent, was intimately connected for many years with the Soho

works, and died unmarried at Aston Hall, Birmingham, June 2, 1848.

With the dissolution of partnership in 1800 and the retirement of Watt from active participation in the work of the firm our sketch of Watt's personal career must close. He was granted a score of years to enjoy the fruits of his labours, and like Bessemer he left the development of his great invention to younger men. With the birth and growth of the locomotive and of steam navigation he had little to do. The stately beam engine was almost entirely his creation, and it remains to-day perhaps the most fascinating of all prime movers. Still Watt's retirement was no period of stagnation. With leisure came better health and he grew old, retaining and exercising his inimitable powers of invention to the end. His wonderful memory, and his inexhaustible fund of information were remarked by all, and most of his eulogists gained their impressions of Watt in his later years. At the time of his retirement Watt was 64, but Brougham was only 21, Scott 29 and Lord Jeffrey but 27. "This potent commander of the elements, this abridger of time and space, this magician whose cloudy machinery has produced a change in the world, the effects of which, extraordinary as they are, are only now beginning to be felt" appealed to the younger generation as no other man of his time did. They saw in him the transformer of society and when he died there was a gap in the intellectual world such as was caused by the death of Newton.

NOTES ON FIGS. 6 AND 7.

Fig. 6, Title.

Section of the steam engine on Mr. Watt's construction, lately erected at New Willey furnace, near Brosely, Shropshire, by Mr. John Wilkinson, and used for blowing air into his smelting furnace at those works.

Table of References.

A.—The boiler.
B.—The steam pipe communicating at all times with the upper part of the cylinder C C C C, and, when the valve *h* is open, with the lower part also through the tube D.
C C C C.—The house cylinder.
D.—The tube for opening a communication to F through *h*.
E.—The piston of the house cylinder.
F.—The communication pipe by which a passage is opened occasionally between the house cylinder and the condenser Q.
I I.—The cistern filled with cold water and surrounding the condenser.
Q.—The condenser.
K.—The piston of the condenser, with its valves.
L L.—The beam of the engine.
M.—The pivot on which it moves.
N N N N.—The blowing cylinder or pump.
O O.—The piston with its valves.
P P.—The pipes through which the air is forced into the regulating bellows.

This section is supposed to be made at the instant the pistons E and K are at their greatest height, and the piston O at the bottom of the blowing cylinder. The steam passing from the boiler A through the pipe B into the upper part of the cylinder Ca, presses on the piston E, and a vacuum being formed in the condenser Q by the rising of the piston K, and a communication opened through F by the opening of the valve *g*, the steam which occupied the space from E to C rushes into the condenser, and piston E, meeting little or no resistance, is pressed down by the force of the steam to C*b*, when the valve *g* being shut and *h* opened a communication is made between the boiler A through D and *h* under the piston E, which then being surrounded on all sides with steam, rises by the weight of the piston and rod O and thus a reciprocating motion is continually kept up. The water condensed in the vessel Q is taken up by the piston K and discharged at the top of the condenser.

Fig. 7, Title.

Section of the blowing cylinder and one of the regulating bellies, used at Mr. Wilkinson's iron furnace, at Willey, near Brosely, Shropshire.

Table of References.

A.—The end of the beam of the fire engine.
B B B B.—The blowing cylinder with its piston and valves C C C C.
D.—The communication pipe with its valve *d*, through which the air is forced from B to the regulating belly E E, which stands on arches within the vessel F F F F, which is filled with water to Z Z.
G.—A cast-iron pipe through which the air is driven by the opening L into the furnace.
I.—A leathern joint by means of which the pipe H I can be turned to any direction when it is necessary to stop the blast into the furnace.
K.—An arch of brickwork to support the pipe H I.
M.—A mass of brickwork to prevent the regulating belly blowing up.
d.—A valve to prevent the return of the air from the belly during the descent of the piston C.

This section is supposed to be made at the instant that the beam A and the piston C are at their greatest descent. On their arising again, the valves shut, and the air contained in the blowing cylinder is forced through the pipe D into the regulating belly E, and not being discharged through opening L so fast as it enters at *d* the water in the belly is driven from the dotted line Z to *f*, and in the cistern from Z to O. As during the descent of the piston C no air is forced through *d*, the endeavour of the water to return to its level at Z serves effectually to keep up a constant blast at L. The sides of the regulating bellies and the walls of the cistern are brickwork bound together with iron, notwithstanding which it has been found necessary to load the belly with a solid mass of brickwork to prevent the danger of blowing up.

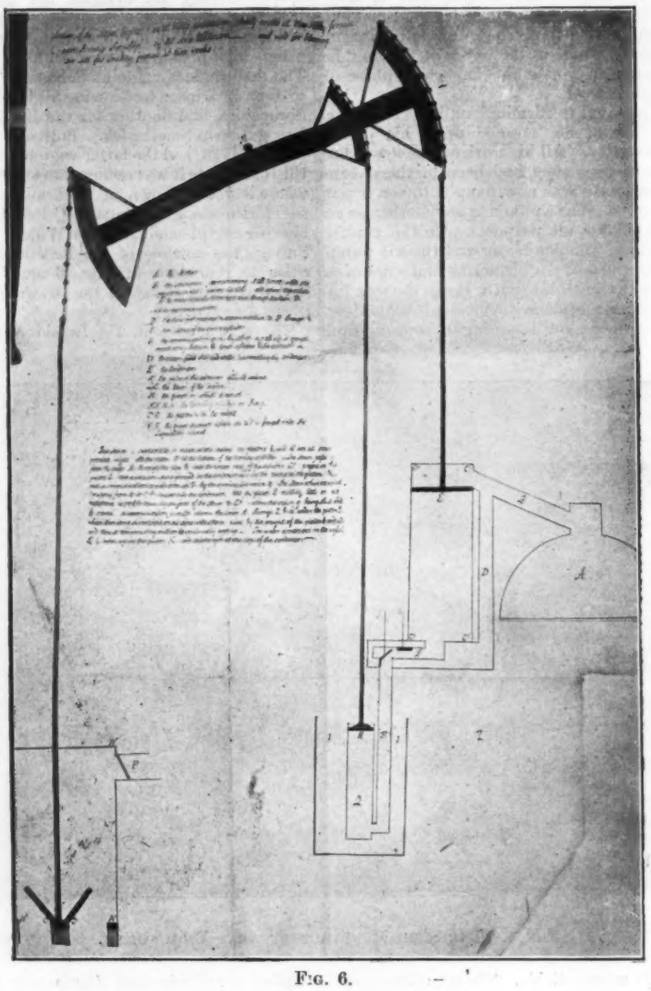


FIG. 6.

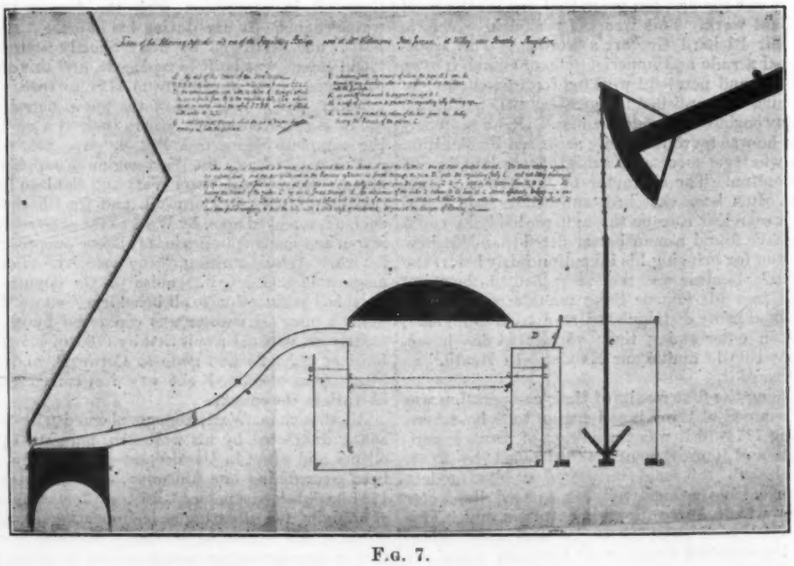


FIG. 7.

The England of Watt's active career was, however, not the England of Scott, of Brougham, of Lamb and Coleridge, but rather that of Johnson, of Gibbon and Wesley. The year Watt entered Morgan's shop saw the completion of Johnson's famous Dictionary. While Watt was pondering over the model of Newcomen's engine, Gibbon was wandering amid the ruins of Rome and beginning those studies which gave us the "Decline and Fall of the Roman Empire." Just as Watt emerged from a score of years of vexation, struggles, ill-health and despondency, John Wesley, still vigorous and able to ride 70 miles a day, was handing down to posterity the remarkable religious Society to which the world owes so much. Watt's scientific contemporaries included Black, Hutton, Priestley, Cavendish, and a score beside, among whom were Banks and Herschel. The lives of Banks and Herschel cover, with a year or two, the same period as Watt's. Both at home and abroad it was an age of intellectual distinction, and the great extensions of mathematical science which took place in France had its parallel in the advance of practical mechanics in our own land. Our industrial revolution, too, ran parallel with the French political revolution, and in the end proved the more powerful. In this industrial revolution Watt is certainly the outstanding figure, but it is only right not to forget the work of his fellows. The steam engine would have come had he never lived, but its development would have been later. Men, horses, wind and water were proving quite inadequate to meet the needs of the day and the Newcomen engine, with its consumption of 28 lb. of coal per horse-power was but an unsatisfactory substitute. The insistent demand then, as now, was for power, and Watt's pre-eminence lies in the unrivalled combination of manual dexterity, inventive genius and scientific knowledge, with which he was able to attack the greatest problem of the times. His series of splendid inventions, his patents of '69, of '81, '82 and '84, gave the miner his pump, the smelter his blast, the weaver his power-house. Kay, of Bury, with his flying shuttle, Hargreaves with his jenny, Arkwright with his spinning machine, Crompton with his mule and Cartwright with his power loom, were all among the men who broke up "the long ice age of hand working" and provided one of the greatest fields for Watt's engines. Darby and Wilkinson, Huntsman and Cort, were all contemporary with Watt. It was Wilkinson who bored the cylinders for Boulton and Watt, Huntsman who supplied them with steel, and it was to Watt that Cort went for an engine to drive his rolling mill. The effect of the inventions of Watt and his fellows in securing for ourselves a place in the sun, has been fully recognised by many historians, and not least by Lecky in his, "History of the Eighteenth Century." "Gradually," says Lecky, "during the last twenty years of the century this new engine came into use as the motive power in manufactures, performing with enormously increased strength and efficiency what had formerly been done by human muscles, by animals, by wind and by water. No other invention since the discovery of printing has affected so widely, so variously and so powerfully the interests of mankind . . . the triumphant issue of the Great French War was largely, if not mainly due to the cotton mill and the steam engine. England might well place the statues of Watt and Arkwright by the side of Wellington and Nelson, for had it not been for the wealth they created she could never have supported an expenditure which during the last ten years of the war averaged more than 84,000,000*l.* a year and rose in 1814 to 106,000,000*l.*, nor could she have endured without bankruptcy a national debt which had risen in 1816 to 884,000,000*l.*"

Fairbairn, when unveiling the statue of Watt at Manchester, in 1857, remarked that "the smallest honour we can do the great benefactors of mankind is occasionally to bring them to our recollections," and it may safely be said that of all the benefactors Fairbairn would have us remember there would be none more worthy of our homage than James Watt the "Improver of the Steam Engine."

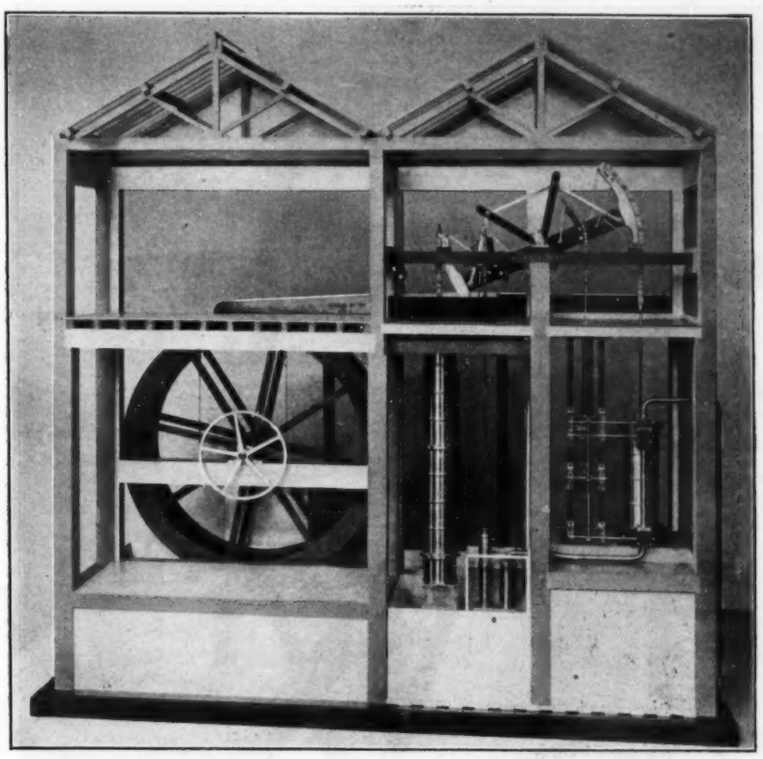


FIG. 8. MODEL OF THE "OLD BESS" ENGINE AT SOHO, 1777.

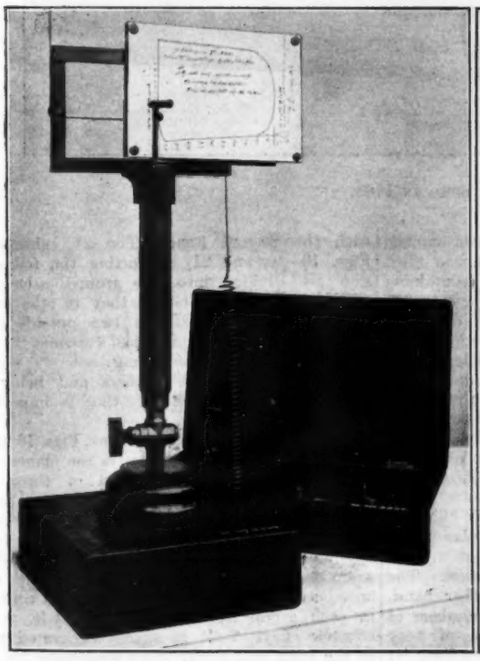


FIG. 9. WATT STEAM ENGINE INDICATOR WITH CARD TAKEN BY MR. E. A. COWPER IN 1840.

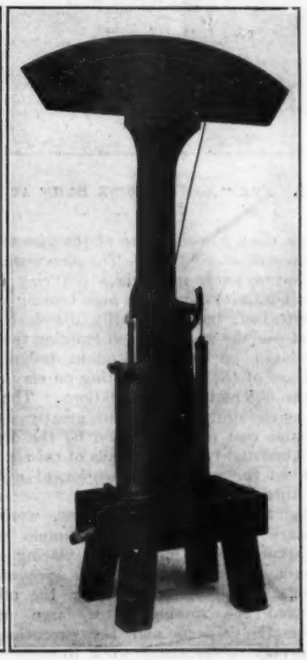


FIG. 10. THE WATT VACUUM GAUGE.

IMPROVEMENT OF KIANGNAN DOCKYARD, SHANGHAI.—We read in *The London and China Telegraph* that as the result of its contract with the American Government, the Kiangnan Dockyard, according to the Far Eastern press, has been enabled to effect very great changes and improvements. The yard itself has been enlarged and extended, having now a river frontage of nearly a mile. New offices, machine shops, foundry, boiler shops, &c., have been erected, and equipped with the latest appliances and tools. The whole yard is being electrified, pneumatic riveters, with the necessary plant, are being installed. New plant and tools arriving by every steamer are being erected. Special and very powerful tools, designed by the dockyard officials themselves, are being completed, and shortly it is hoped that the Kiangnan Dockyard will be the largest and most up-to-date in the whole of China. A special feature of the establishment will be the new foundry. Owing to the nature of the soil special precautions have to be taken in the case of heavy castings in Shanghai. In the case of the new Kiangnan foundry the casting pits are of cement, floated in the soil while the bottom of the pit is protected by a removable iron base in segments. The cupolas are so arranged that the molten metal can flow directly into the pits, thereby doing away with the necessity of a casting ladle.

WATT'S "LAP" ENGINE AT SOUTH KENSINGTON MUSEUM.

(*For Description, see Page* 229.)

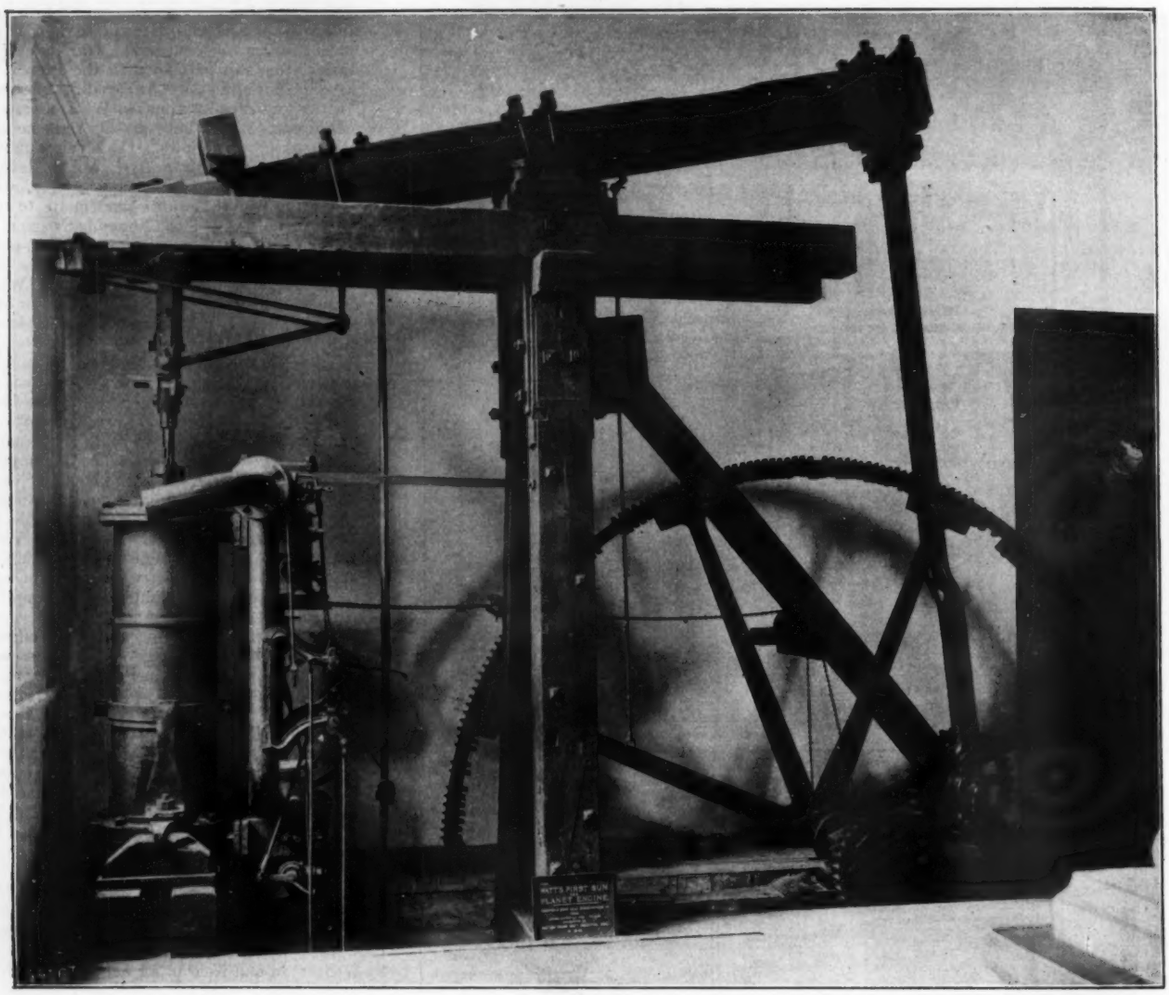


Fig. 41. The "Lap" Engine Built at Soho in 1788.

HELL GATE BRIDGE, NEW YORK.

By Frank W. Skinner, M.Am.Soc.C.E.

(*Continued from page* 172.)

Foundations.

The towers are apparently duplicates, and in reality are alike above the surface of the ground, but below that level differences in the sites at the opposite ends of the spans required corresponding differences in construction and involved great difficulty and expense for the foundation of the western or Ward's Island tower. The east or Long Island tower has a simple monolithic concrete foundation, 104 ft. wide by 140 ft. long, with an average thickness of 49 ft. resting on solid bed rock, encountered from 15 ft. to 38 ft. below the surface and loaded to a maximum pressure of 8½ tons per square foot. This foundation was built without difficulty in open excavation.

On Ward's Island preliminary explorations by wash borings and by core borings indicated the surface of the rock to be from 15 ft. to 140 ft. below mean high-water level. Subsequent development showed that the site here was crossed by two separate formations of dolmitic limestone and of gneiss rock with approximately vertical stratification and extending in a direction oblique to the axis of the bridge. The two formations are separated by a crevasse from 15 ft. to 60 ft. wide on top, that passes close to the centre of the pier and extends to an unknown depth. The crevasse was filled with very hard, impervious red clay (containing some boulders) that had a high bearing power when undisturbed, but was easily dissolved in water. Great courage was shown in building the important foundation on this site, and in designing it with portions of the bearing resting on clay and others on the different rock foundations. The plan that was successfully carried out greatly reduced the probable cost of construction by the development of an unusual type and details of caisson work, but involved the very able execution of difficult substructure operations.

The Long Island foundations, were built by ordinary methods involving simple plans and operations for the mixing and placing of a large amount of concrete in open excavation. The Ward's Island foundations, on the other hand, involved the sinking of a large number of pneumatic caissons and the execution of very important subterranean work to connect them far below the surface of the ground and below the water-level in the adjacent river. On these caissons there is supported a monolithic, foundation slab, 143-ft. by 119-ft. and 40 ft. thick, that carries the great tower shaft.

The details of the Ward Island foundations are shown in Figs. 16 to 27 on Plate XIII, published with the present issue. The 21 caissons (see Figs. 16, 20, and 21) supporting the foundation slab are divided into five groups, each group with its axis parallel to that of the bridge. The centre group and the two outside groups each consist of five cylindrical caissons, 18 ft. in diameter, each caisson being entirely separate and independent of the others and being subjected to a vertical load only that is imposed by the weight of the tower.

The two other groups of caissons, Figs. 16 and 20, located with their centre lines in the planes of the arch trusses, are each formed of three equal rectangular caissons connected together and making 29·53 ft. by 125·89 ft. continuous structures calculated to resist the horizontal thrust of the arch truss. The 30-ft. by 41-ft. separate caissons were sunk independently, end to end, with clearance between them, and were afterwards connected in each group by two 16-ft. by 6½-ft. vertical concrete keys built in spaces excavated partly in the open and partly under pneumatic pressure, after the caissons had been sunk to their final positions.

All of the caissons were made with 1 : 2 : 4 concrete and were thoroughly reinforced with vertical and horizontal steel rods. The cylindrical caissons, 18 ft. in diameter, were built with an annular concrete shell, 5 ft. thick, and an 8-ft. open

HELL GATE BRIDGE, NEW YORK: THE MAIN TOWERS.

MR. GUSTAV LINDENTHAL, CHIEF ENGINEER.

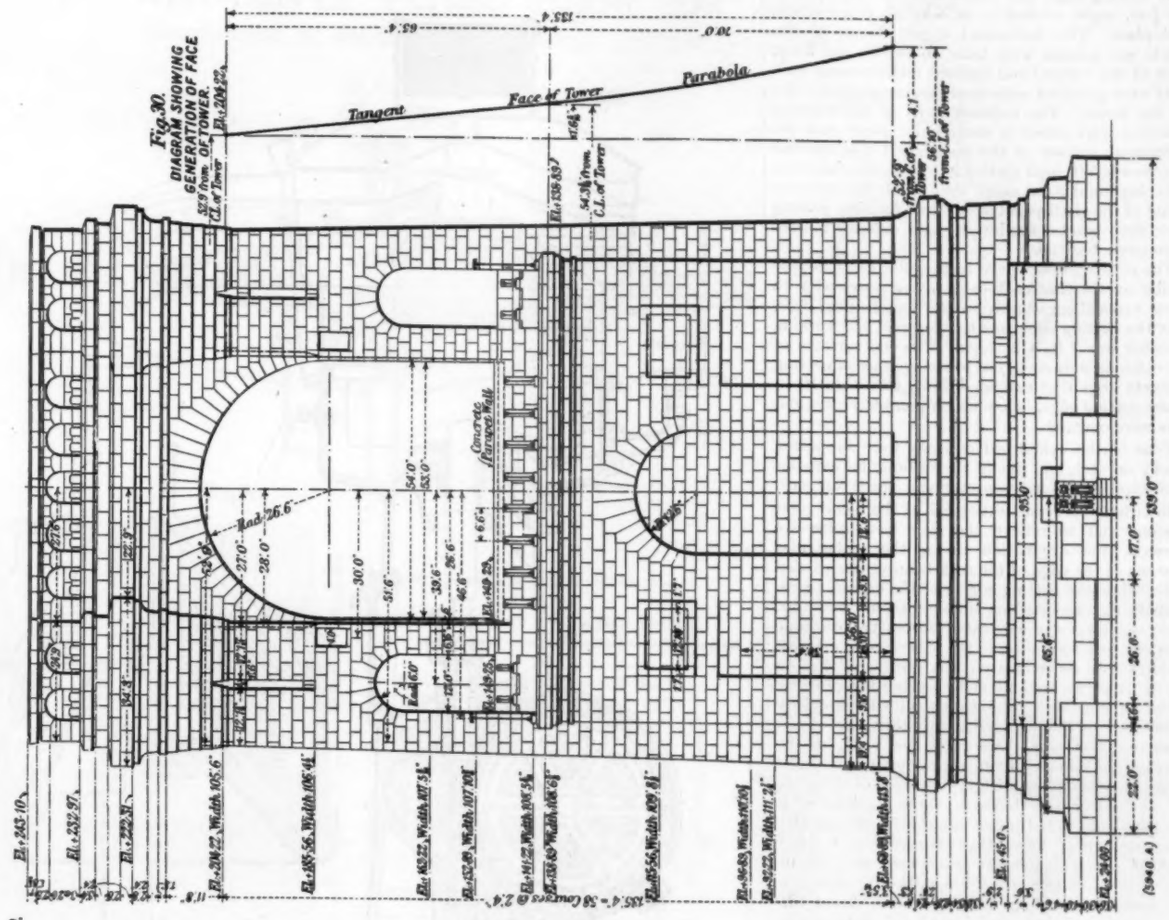


Fig. 29.

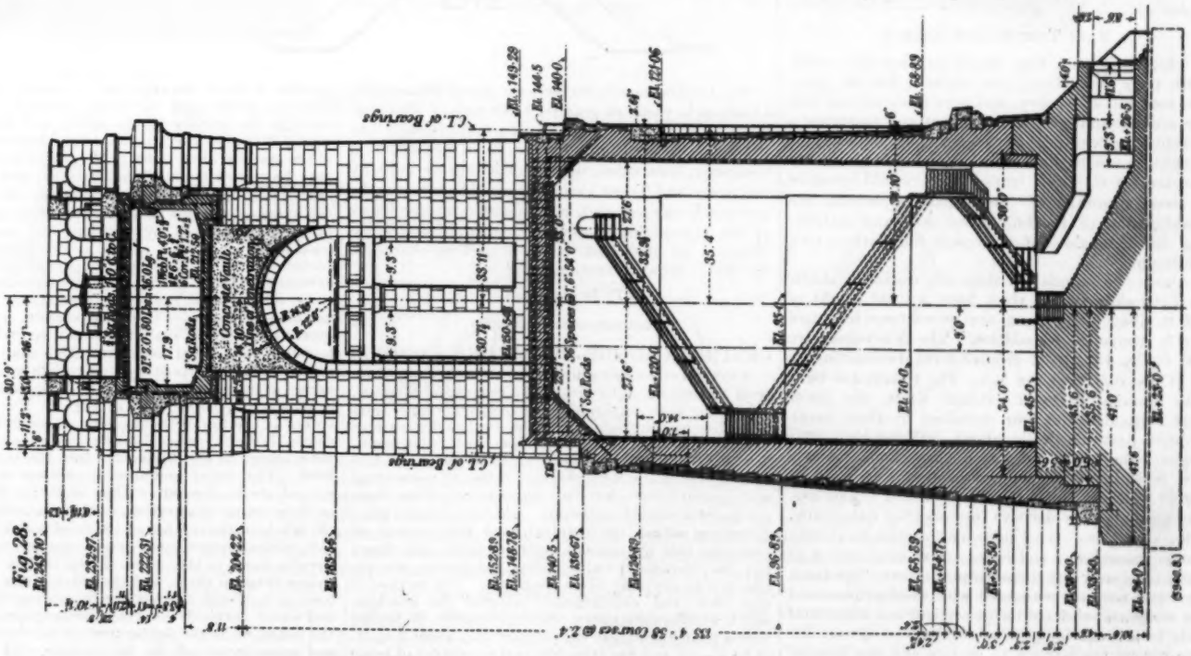


Fig. 28.

central shaft filled like the working chamber with concrete after the caisson was sunk to position. The cutting edge was made with a 4-in. by 4-in. by ⅞-in. angle, riveted to an 8-in. by ½-in. vertical web-plate. The horizontal upper flange of the angle was pierced with holes to receive the lower ends of the vertical and inclined reinforcement rods that were provided with nuts bearing on both sides of the flange. The inclined walls of the working chamber were offset in rectangular steps, and the cylindrical surface of the open shaft was divided into panels 5 ft. high vertically by annular channels, 9 in. high and 3 in. deep, into which the concrete filling of the shaft penetrated, thus forming joining keys that bonded the interior and exterior masses of concrete together.

The construction of the rectangular caissons was similar except that each caisson was provided with three vertical air shafts on the longitudinal axis, that the cutting edge was heavier, and the working chamber was 7 ft. 4 in. high. The end surfaces of the caissons were cored out to receive the connecting concrete keys that extended down to within 10 ft. of the cutting edge, below which point the cores and keys were omitted.

Four of the cylindrical caissons were supported wholly on clay, and five of the rectangular caissons were supported partly on clay and partly on rock.

In order to prevent settlement of the rectangular caissons and to relieve the clay from excessive pressure, the excavation under the rectangular caissons at the edge of the rock bearing was carried down below the cutting edge and the caissons were temporarily supported on rubble masonry columns, while the clay was excavated across the crevasse from one rock formation to the other, and a massive subterranean concrete arch was built abutting on the two rock formations and carrying the portions of the caissons above it so that the load was chiefly transferred to the solid rock on either side of the crevasse. The upper part of the clay in the crevasse was trimmed to an approximate cylindrical surface corresponding with the intrados of the arch, and the latter was built in three sections with approximately radial joints off-set with rectangular steps providing keys that thoroughly bonded together concrete laid in different operations. About 30 per cent. of the entire foundation is over the clay formation. About 25 per cent. rests on the gneiss rock, and the remaining 45 per cent. on the limestone rock, where it exerts a maximum theoretical pressure of 20 tons per square foot, ignoring skin friction and possible hydrostatic uplift.

Main Towers and Shafts.

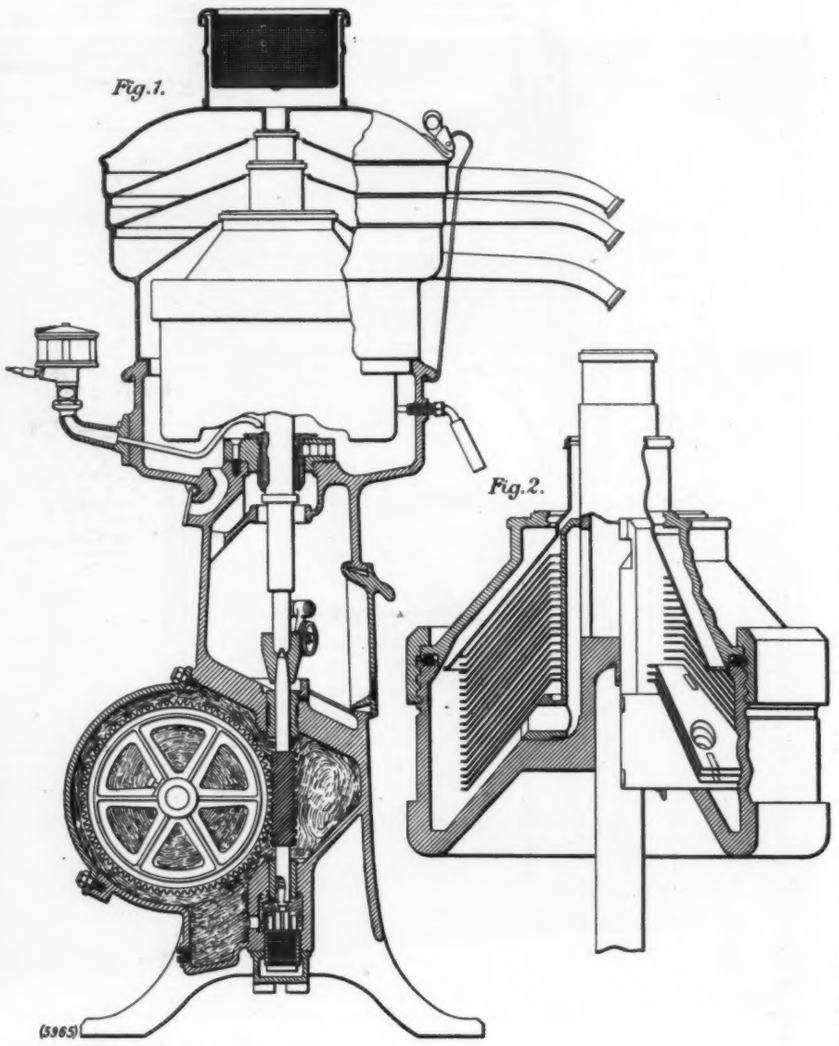
The main towers, Figs. 28 and 29, page 237, which, with their foundations cost about 1,700,000 dols., are very tall and heavy, and were designed not only for architectural and artistic effect and to secure a massive appearance, but also to increase the weight so much that combined with the inclined reaction of the arch trusses they would produce a steep resultant of forces passing within the middle third of the foundation area and restricting the dimensions of the costly foundations to a minimum.

Above the foundation slabs the duplicate shafts on both sides of the river have a total height of 220 ft. above the ground, and an extreme height of 345 ft. above the foundation. The dimensions are 103 ft. by 139 ft. at ground level diminishing to 61 ft. by 105 ft. at the top. The towers are built with massive battered exterior walls, the lower part is divided into four chambers by three longitudinal partition walls about 100 ft. high that support the heavy reinforced track floor. Above this level the walls are ornamented with exterior corner pilasters and heavy cornice moulding, terminating in a massive ornamental balustrade. They are pierced on all sides with arches just below cornice mouldings, and there are smaller arches at track level over the sidewalk platforms. The track floor and roof are reinforced with steel girders, and the walls are reinforced with vertical and horizontal rods to prevent temperature and shrinkage cracks. The towers are faced with granite and the interior spaces are accessible by stairs leading up and down from the track floor.

The towers contain 99,000 cub. yards of concrete, 11,000 cub. yards of granite, 1,000 tons of reinforcement steel and 500 tons of structural steel. The tower bases were built by the Ryan Construction Company, contractor, upper portions were built by the Snare and Triest Company, contractor, and the pneumatic caisson work was executed by the forces of the Connecting Railroad Company, under the direction of its chief engineer and in charge of Mr. B. G. Brown, managing engineer.

(To be continued.)

DE LAVAL CENTRIFUGAL OIL PURIFIER.



CENTRIFUGAL OIL PURIFYING MACHINE.

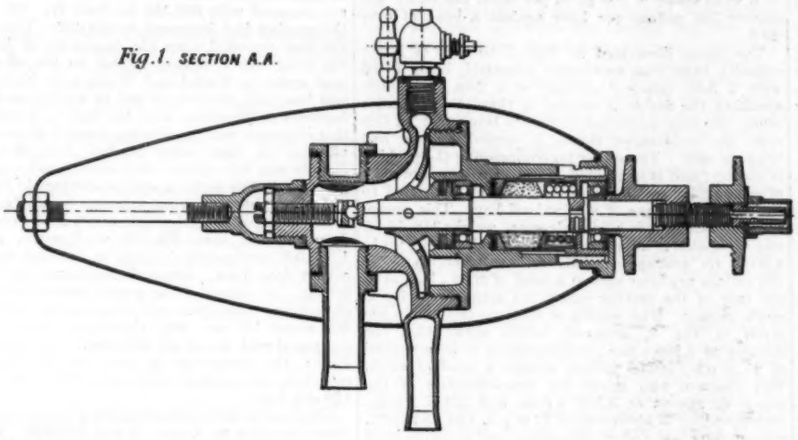
A system of removing dirt, water and other impurities from lubricating oil by means of a centrifugal machine, similar to that employed for separating cream from milk, has been introduced by the De Laval Separator Company, of 165, Broadway, New York, who manufacture the machines used for the purpose. The system has many advantages for use in connecting with geared turbine installations, especially when these are used for marine propulsion. For this purpose large quantities of oil are required, and the method of purifying this by means of settling tanks and filters has the obvious drawback that the former are ineffective in anything like a rough sea. The method is also slow and cumbersome, whereas the machine which we illustrate above, although capable of dealing with a large quantity of oil, occupies only about 2 sq. ft. of floor area, and has the additional advantage of being quite unaffected by the motion of the ship.

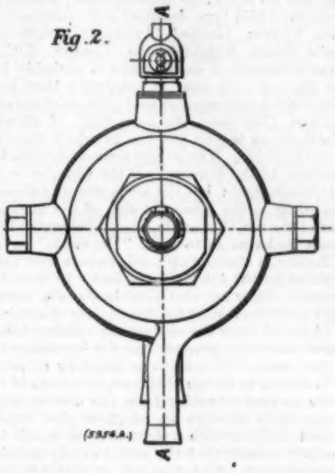
In marine geared turbine installations the centrifugal purifier is fitted between the overhead supply tanks and the drain tank, oil being led from the former through the purifier to the latter, and the piping is arranged so that the attendant can observe the action of the machine at all times. All, or only part, of the oil may be passed through the machine, and, as the oil and water are completely separated, the attendant can at once detect the presence of an abnormal quantity of water in the oil by watching the discharge. A leakage of water from the oil cooler, or from water-cooled bearings if these are employed, is thus made evident, so that it can be promptly remedied.

As will be seen from our illustration, Fig. 1, the machine comprises a pedestal casting, in which is mounted a vertical shaft running in specially-designed footstep and radial bearings. The shaft, which is driven at a high speed by quick-pitch worm gearing, carries at its upper end a bowl, the construction of which is shown to a larger scale in Fig. 2. The impure oil enters at the top of the machine, through the strainer shown in Fig. 1, passes downwards through the central tube, shown in Fig. 2, and out into the bottom of the bowl. The latter contains a number of truncated conical shells, formed of thin sheet metal, arranged as shown in the illustration, so that they fill practically the whole of the interior of the bowl and divide it into thin conical spaces. Oil passes upwards through the circular holes in the cones, shown in Fig. 2, into the spaces between them, and the effect of the centrifugal force is to throw the heavier impurities, such as dirt and water, outwards into the annular space surrounding the cones, while the lighter purified oil travels inwards and upwards towards the central tube. Of the heavier impurities, the solid matter is retained by centrifugal action on the periphery of the bowl, whence it is

WIND-DRIVEN PETROL PUMPS FOR AEROPLANES.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, AVIATION DEPARTMENT, LONDON.





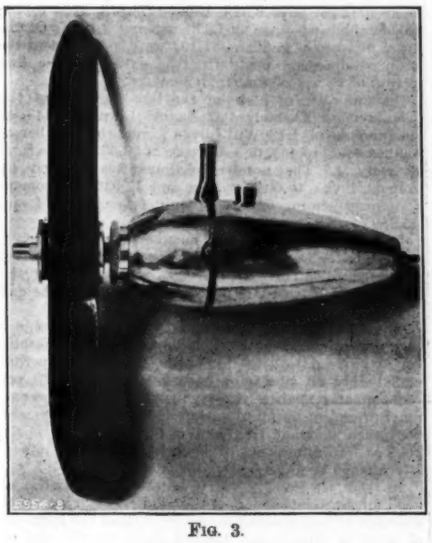


FIG. 3.

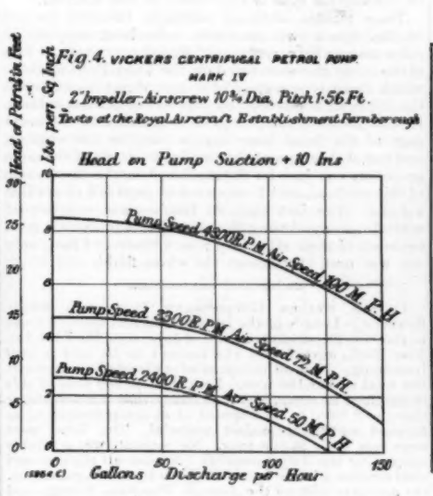


Fig. 4. VICKERS CENTRIFUGAL PETROL PUMP MARK IV
2 Impeller Airscrew 10⅜ Dia, Pitch 1·56 Ft.
Tests at the Royal Aircraft Establishment Farnborough
Head on Pump Suction + 10 Ins
Lbs per Sq Inch
Head of Petrol in Feet
Pump Speed 4800 R.P.M. Air Speed 100 M.P.H.
Pump Speed 3300 R.P.M. Air Speed 72 M.P.H.
Pump Speed 2400 R.P.M. Air Speed 50 M.P.H.
Gallons Discharge per Hour
0
50
100
150

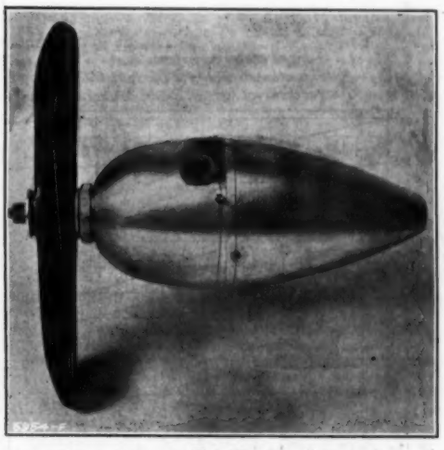
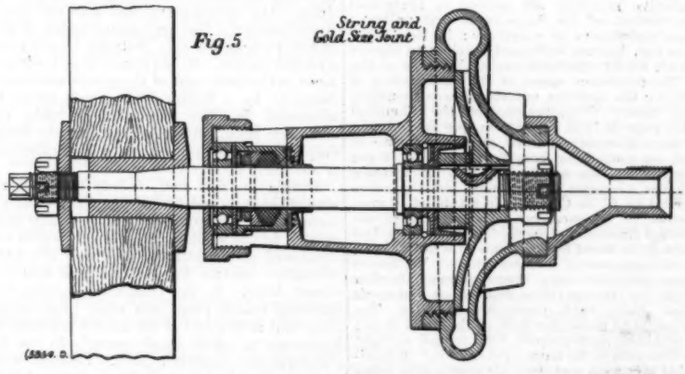
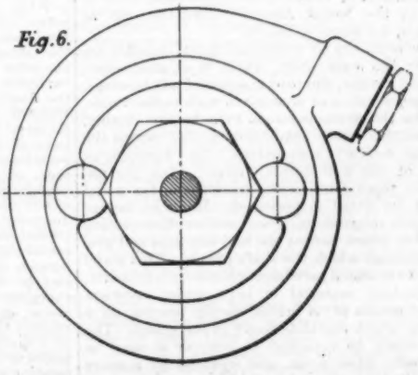


FIG. 7.





removed at intervals, while the water passes upwards and out through the lowest outlet into a pan provided with a spout, as shown in Fig. 1. The pure oil leaves by the intermediate outlet, and the third outlet only comes into use if the bowl should become clogged with dirt. In this case, the oil, after filling up the central tube, would overflow into the uppermost collecting pan, and, by flowing out of the spout from this pan, would at once warn the attendant that the bowl required to be cleaned out.

Purifiers suitable for marine work are made in two standard sizes capable of dealing with about 100 gallons and 300 gallons per hour, respectively, but the capacities of the machines naturally vary somewhat according to the viscosity of the oil treated. They are arranged for driving by electric motor or by means of a small steam turbine built into the pedestal casting, the latter arrangement giving a very compact and convenient unit. The sole agents for these machines for marine use in Great Britain and Ireland, are Chadburn's (Ship) Telegraph Company, Limited, of Cyprus-road, Bootle, Lancashire.

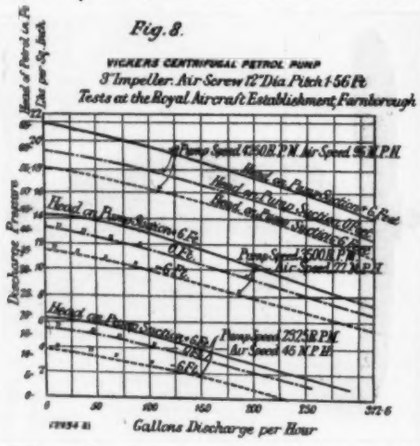
PETROL PUMPS FOR AEROPLANES.

In the early days of aeronautics, when low-powered engines were employed on machines intended for flights of only a few minutes' duration, the supply of petrol to the engine was a matter of extreme simplicity. Nowadays, owing to the use of large machines requiring two or more engines, each of several hundred horse-power, for flights lasting many hours, the problem of ensuring an adequate and unfailing supply of petrol to the engines is one which has to be considered seriously by the designer. The main supply of petrol is usually carried in large tanks fitted in the fuselage, and it is supplied to the carburettors, by gravity, from service tanks placed at some high point in the structure of the machine—often inside the upper main plane. The service tanks, which are of small capacity, have to be kept filled by pumping from the main tanks, and evidently the reliability of the pumping arrangements is a matter of the utmost importance, since a failure in the petrol supply must result in a forced landing. Several appliances, using different mechanical and

aerodynamical principles, have been employed for raising the petrol into the service tanks, and, of these, the one which seems to have been found most generally satisfactory is the wind-driven centrifugal pump.

On page 239 we reproduce drawings and photographs of two pumps of this type designed and manufactured by Messrs. Vickers, Limited (Aviation Department), of Imperial Court, Knightsbridge, London, S.W. 3. The overall efficiency of such pumps is probably low, but from the point of view of reliability they leave little to be desired, and as compared with mechanically-driven pumps, they have the advantage of allowing greater latitude as to the position in which they are fitted on the machine. The pumps are usually attached to the fuselage, to the front spar of the wing, or to one of the interplane struts, but the arrangement naturally varies according to the general design of the machine. In any case they are, if possible, placed below the level of the main tanks so as to work "drowned," as this avoids difficulty in starting up; otherwise a foot valve must be fitted in the inlet pipe in order to keep the pump primed. They are also fixed in the slip stream of the main propellers, more for the purpose of ensuring a supply of petrol when the engines are running before the machine leaves the ground than for increasing the speed of the pump. Actually the quantity of petrol delivered is always in excess of the requirements of the engines, the surplus returning from the service tanks to the main tanks through an overflow pipe, which, in some cases, is fitted with a sight tube to enable the pilot to satisfy himself that the petrol supply is being properly maintained. Figs. 1 and 2, on page 239, are, respectively, a longitudinal section and end elevation

Fig. 8.


VICKERS CENTRIFUGAL PETROL PUMP
3 Impeller. Air Screw 12' Dia Pitch 1-56 Ft.
Tests at the Royal Aircraft Establishment, Farnborough
Head of Petrol in Ft. Lbs per Sq. Inch
Discharge Pressure
Gallons Discharge per Hour
372·6

of the smaller of the two pumps, which is provided with an impeller 2 in. in diameter. The general appearance of this pump is shown by the photograph reproduced in Fig. 3, while the results of some tests on it, made at the Royal Aircraft Establishment at Farnborough, are given in Fig. 4.

As will be seen, the air screw and pump impeller are mounted on the same shaft, which is of steel, case-hardened and ground, and runs in a pair of ball bearings. The impeller, which is of aluminium with radial vanes, is pinned to the shaft and runs in a bronze casting, which forms the volute chamber and also carries the suction and delivery connections. The connections shown are of the well-known "olive" type, for use with flexible pipes, but screw connections, for metal tubing, can be fitted if preferred. Into the bronze casting, above referred to, is screwed another casting of aluminium, which carries the ball bearings and also the gland through which the shaft passes. This gland is packed with asbestos yarn impregnated with graphite, and the packing material is kept under constant pressure by means of a helical spring bearing on a packing ring, which can slide freely in the gland. The gland can easily be repacked *in situ*, or it may be removed bodily when worn, and replaced by a spare part. The body casting, it will be noticed, is split longitudinally so that it grips the ball bearing and movable gland firmly when the cap is screwed up. The thrust of the air screw is partly balanced by that of the petrol on the impeller, and the residual thrust is taken on a single steel ball at the end of the shaft, as shown in Fig. 1. This ball can be adjusted in a longitudinal direction by means of a screw, and thus serves to fix the position of the impeller in the volute chamber. The latter is provided with four tapped bosses for fixing, and is also fitted with a small pet-cock to allow any air, which may become trapped in the casing, to escape. The whole is enclosed in a spun aluminium casing, of stream-line form, made in two parts and attached to the pump as shown in Fig. 1. The weight of the pump, complete with a two-bladed air screw, is 2 lb., and its guaranteed delivery is 50 gallons per hour against a head of 10 ft. when running at 3,200 r.p.m. The actual capacity is, however, greatly in excess of this, as will be seen by the diagram, Fig. 4. This shows that, when running at 4,300 r.p.m., in a wind speed of 100 miles per hour, the pump will deliver 100 gallons per hour against a head of over 20 ft.

The pump illustrated in Figs. 5 to 7 is of larger capacity than that previously described, being fitted with a 3-in. impeller, instead of a 2-in. Generally speaking, the design is similar to that of the smaller pump, the only important difference being that, in this case, the unbalanced thrust is carried by the ball bearings only. The spring for compressing the packing is shorter, and is composed of only two turns of steel of rectangular section, and the impeller is secured to the shaft by means of a Woodruff key. This pump, complete with a four-bladed air screw, weighs 3 lb. 10 oz. and is capable of supplying engines of all powers up to 4,000. Its guaranteed delivery, at 3,200 r.p.m., is 150 gallons per hour against a head of 25 ft., but, as in the case of the smaller pump, its actual capacity is much greater. The results of tests on this pump are given in Fig. 8, annexed, which shows that the delivery at 4,250 r.p.m., corresponding to an air speed of 95 m.p.h., is 300 gallons against a head of 40 ft. This diagram also shows the characteristics of the pump at speeds of 3,500 r.p.m. and 2,325 r.p.m., corresponding to air speeds of 72 m.p.h. and 45 m.p.h., respectively. The effect of positive and negative head on the suction pipe is also shown in this diagram.

These pumps, although originally intended for use on the firm's own machines, have been supplied to other makers for aeroplanes of almost every type. Two of the larger size were fitted on the Vimy-Rolls machine which recently completed the first direct flight across the Atlantic, as recorded on page 811 of our last volume. In this machine, the pumps were attached to the lower part of the front inner struts carrying the engines, and one of them, partly hidden by the blade of the main propeller, can just be distinguished in the illustration of this machine, which appeared on page 606 of our last volume. The fact that no trouble was experienced with the pumps during this remarkable journey is good evidence of their reliability; as a matter of fact, only one was used throughout the whole flight.

United States Government Iron and Steel Surplus.—Details of the surplus iron and steel on hand in the War Department at end of July, says *The Iron Age*, New York, reveal that the amount to be sold is still increasing. New adjustments of contracts have brought the total to 883,166 tons. Less than 40,000 tons of this is itemised as scrap, but it is likely that a much larger share will have to be disposed of as scrap instead of as finished and semi-finished material. The June sales were less than 80,000 tons. No estimate was available concerning the July prospects. Almost all the iron and steel surplus is in the hands of the Ordnance Department, the amounts held by the Aircraft, Purchase, Storage and Signal Corps Divisions being relatively small.

Propagation of Flame in Acetylene-Air Mixtures.—When explosive mixtures are ignited in horizontal tubes the movement of the flame is at first uniform, then becomes undulatory or vibratory; in long tubes the vibrations may become sufficiently violent to shatter the tube which would otherwise resist the force of the explosion. The maximum speed of the propagation of the flame during the uniform movement was found by Haward and Sastry (Transactions of the Chemical Society, 1917, page 841) to be 260 cm. per second in a tube of 12 mm. diameter charged with a mixture of acetylene and air containing from 8 per cent. to 10 per cent. of acetylene. The speed is known to increase slightly with the diameter of the tube, but the value of 600 cm. found by H. Le Chatelier in a tube of 40 mm. diameter seemed to be excessive. In large tubes the electric method of Haward and Sastry (fine wires stretched across the tube to be fused by the flame) did not answer, because the uniform period was too short. W. Mason and R. Vernon Wheeler have therefore made further experiments in the Home Office Station at Eskmeals (same Journal, June, 1919, pages 578 to 587). The method they use is to cause the light of the flame to act on a highly-sensitive photographic film, moved at right angles to the direction of the flame propagation. Experimenting in this way with acetylene-air mixtures in tubes of 12·5 mm., 25 mm., 50 mm. and 90 mm. diameter they found that the maximum speed increased with increasing diameter from 270 cm. up to 335 cm. per second. The excessive value of Le Chatelier is thus not confirmed, and it is suggested that the error is due to the fact that the end of the uniform movement is difficult to observe. They made another interesting observation. Even the uniform movement shows sometimes slight undulations caused probably by the fact that the first igniting spark may be followed by others which set up resonance vibrations in the gas column. To avoid this vibration they ignited the gas by introducing a hydrogen jet into the end of the tube or holding the jet in front of the tube. The undulations are too small to be directly visible, but they can sometimes be traced, after the explosion, by a succession of rings of moisture deposited at regular intervals along the tube. This effect had, in fact, already been noticed by Neyreneuf in 1880.

INDUSTRIAL NOTES.

During the first part of July, says *The Labour Gazette*, the state of employment continued to improve, and on July 25 the number of unemployed persons, as shown by the donation records, had fallen to 540,884, as compared with 606,125 on June 27. On August 1 the number had increased to 553,482. This increase, the first recorded since the beginning of May, when the total was 1,093,400, is due to the effect of the coal strike in Yorkshire. Workers at blast furnaces and iron and steel works and in woollen and worsted factories in Yorkshire were the first to be affected by this stoppage, and the slowing down in these industries affected, in turn, other trades. The effect of the dispute was felt all the more acutely, as for some time previous to the strike a serious shortage in the supply of fuel had been reported by a number of firms.

Increases in wages which came into operation in July affected over 200,000 workpeople, and over 1,500,000 workpeople (mostly in the coal-mining and cotton industries) obtained reductions in hours of labour. At August 1 the general level of retail prices of food and other items entering into the cost of living was about 115 per cent. above the pre-war level, as compared with about 105 per cent. at the beginning of June; the percentage is, however, still below that recorded just before the armistice, when it was between 120 and 125.

The total number of persons in receipt of unemployment donation at August 1 was 553,482. The composition of this total was as follows: (*a*) Civilians—men 100,228, boys 6,529, women 73,878, girls 6,176; (*b*) demobilised—men 364,570, women 2,101. Of the total number of civilians 51,194 were in receipt of the reduced donation paid after the expiry of the first period of 13 weeks' unemployment.

The number of men on the live registers of the Employment Exchanges at August 1 was 517,443, or an increase of 1,180 on July 4; and the number of women was 149,464, or a decrease of 33,534 on the total at July 4. The number of vacancies unfilled on August 1 was 40,004 for men and 47,936 for women, the corresponding figures for July 4 being 44,904 and 55,289.

Trade unions with a net membership of 1,341,626, excluding those serving with the forces, reported 2 per cent. of their members as unemployed at the end of July, as compared with 1·7 per cent. at the end of June and 0·6 per cent. a year ago.

The number of workpeople employed at coal mines included in the returns (excluding those in Yorkshire for all three dates) was about the same in the period ended July 26 as a month earlier, and over 20 per cent. greater than a year ago; there was, however, much time lost owing to various causes. Employment continued good at iron and shale mines and fairly good at lead mines, but declined to quiet at tin mines. It remained good generally at quarries.

In the pig-iron industry employment continued good until the latter part of the month, when a general shortage of fuel resulted in one-seventh of the furnaces at work in June being damped down by the end of July. The shortage of fuel affected iron and steel works similarly, the aggregate number of shifts worked in the week ended July 26 being 15 per cent. less than a month earlier. In the engineering trades an improvement in the early part of the month was largely counterbalanced by a decline later, again owing to the coal shortage. In the shipbuilding trade employment remained good, on the whole. In the tin-plate trade employment continued good, and in other metal trades it was fairly good, on the whole.

During the first half of July the cotton trade was almost at a standstill owing to the strike; in the second half employment was generally fair or fairly good. In the woollen and worsted trades employment continued good until the effects of the coal strike in Yorkshire became felt, after which many mills were closed down. In the bleaching, dyeing, printing and finishing trades there was some improvement during July, but at the end of the month shortage of coal was beginning to affect employment. In the brick trade employment continued good. Cement workers were well employed and worked a considerable amount of overtime. In the pottery and glass trades employment continued good; shortage of fuel was reported, and in the Yorkshire glass trade it was so serious as to result in the closing down of several furnaces. In the building trade employment, taken as a whole, was fairly good, and in the wood-working and furnishing trades it was usually good. There was some further improvement in the paper and printing trades; with bookbinders employment was moderate. With dock and riverside labourers employment was fairly good; at most of the principal ports the supply of seamen was in excess of the demand.

The changes in rates of wages reported to the department as having come into operation in July resulted in an increase of over 45,000*l.* in the weekly wages of

over 200,000 workpeople. Changes in hours of labour during June affected about 1,550,000 workpeople, whose recognised working time was reduced by an average of about 5 hours a week; the principal changes affected workpeople engaged in the coal-mining and cotton industries.

The National Union of Railwaymen and the Amalgamated Society of Locomotive Engineers and Firemen had applied for the following wages:—

Drivers and motormen, first and second year, 12*s.* per day; third and fourth year, 14*s.* per day; fifth and onward, 16*s.*

Firemen, first and second year, 9*s.* 6*d.* per day; third and fourth year, 10*s.* 6*d.*; fifth and onward, 11*s.* 6*d.* per day.

Cleaners, 18 and 19 years of age, 8*s.* per day; 20 years of age and over, 8*s.* 6*d.* per day.

The above rates to include all war wages.

This represented in the case of drivers an average increase of 52*s.* 6*d.* per week over their pre-war wage, and of 19*s.* 6*d.* per week over their present wage, which includes war wage, quite apart from any increase of earnings due to the new scales of payment for Sunday duty, overtime, night duty, &c.

The Government then proposed the following scale of pay for drivers, motormen, firemen, and cleaners:—

Drivers and motormen, first and second year, 11*s.* per day; third and fourth, 13*s.*; fifth and onward, 14*s.*

Firemen, first and second year, 8*s.*; third and fourth, 9*s.*; fifth and onward, 10*s.*

Cleaners, 16 years of age, 4*s.*; 17, 5*s.*; 18 and 19, 6*s.*; 20 and over, 7*s.*

This would effect an increase of approximately 100 per cent. on the average standard pre-war rates of pay of the classes concerned.

These proposals were considered by each union separately, then by the two unions jointly. As a result, a communication was made to the Government asking for a meeting to take place at the Board of Trade with a view to discuss the situation further. At this meeting, held last Wednesday, negotiations took place, after which the Government made an amended offer, the new terms, which are accepted by the executives of the two unions, being:—Drivers and Motormen: first and second years, 12*s.* per day; third and fourth years, 13*s.* per day; fifth, sixth and seventh years, 14*s.* per day; eighth year and onward, 15*s.* per day. Firemen and Assistant Motormen: first and second years, 9*s.* 6*d.* per day; third and fourth years, 10*s.* 6*d.* per day; fifth year and onward, 11*s.* per day. Cleaners: as above, proposed by the Government.

The new scale is inclusive of all war wages in the case of engine drivers, motormen and firemen.

Since our statement on page 188 *ante*, on the state of unrest in Liverpool, matters have quieted down at that port, generally speaking. A few days ago, however, a proposal was set on foot for organising a three days' strike shortly, in support of the reinstatement of the policemen who have been dismissed from the service. This proposal led to dissension among members of the different trade unions and will not be given effect to. On the other hand, the policemen in Liverpool are said to be against any sympathetic strike on the part of workers in the town and district.

The Ministry of Health wish to direct the attention of employers and others to the fact that by the National Health Insurance Act, 1919, which has just received the Royal Assent, the limit of remuneration up to which persons employed otherwise than by way of manual labour are liable to compulsory health insurance has been raised from 160*l.* to 250*l.* a year.

Employers are accordingly required for the future to pay health insurance contributions in respect of persons employed by them under a contract of service as follows:—

For non-manual workers, where the rate of remuneration (including any regular bonus, &c.) does not exceed 250*l.* a year.

For manual workers, irrespective of the rate of remuneration.

A non-manual worker whose remuneration is over 160*l.* a year but not over 250*l.* a year may, within a limited period and under certain conditions, claim a certificate of exemption, and on the grant of such a certificate the employer's contributions (3*d.* a week) are alone payable. Forms of application for exemption will be obtainable shortly at any post office.

Speaking on the 13th inst., at the ordinary half-yearly general meeting of the South Metropolitan Gas Company, the chairman, Dr. Charles Carpenter, said that whatever conditions may be applicable to that wrongly-handled industry, the coal industry, he sincerely hoped that they should hear no more about its nationalisation. Mining rights might, however, well be transferred to the State and leased by it to statutory undertakings, such as his company, formed for the purpose of exploiting the principal fields. The mine workers, both above and below ground, should be co-partners with the capitalist in the respective undertakings and with him should have a voice in the management. These proposals he had several times advocated, and particularly five years ago when this country had but just embarked upon that stupendous enterprise—our share in the world war. It was a curious example of the unwisdom of political prophecy to remember that the ruin of the coal industry was declared to be inevitable when a tax of 1*s.* per ton was levied by the late Lord Salisbury's Government upon coal sent abroad in order to provide money for the Navy. He hoped the day had gone never to return when we exported our best coal at the same price as that charged to users at home.

"We were to-day," he added, "faced with a still further extension of our coal difficulties in the announcement that had been recently made of an increase of 6*s.* per ton in the price of coal. We heard a great deal to-day about profiteering. I do hope that our friends of the press, with their usual impartiality, will, when the time comes, as I have no doubt it will between now and Christmas, for us again to raise our price—and I cannot help thinking that our price is likely to be raised to not very much less than 5*s.* between now and Christmas—when that is done I hope our friends will remember that that action will not deserve to be branded as one of profiteering, if they remember at the same time that we are getting six-elevenths of the very moderate pre-war dividend."

The retiring president of the South African Institution of Engineers, Mr. C. D. Leslie, in the course of a valedictory address he delivered at the meeting of the Institution June 18, dealt with the various difficulties which now surrounded the working of the Rand Mines. In regard particularly to labour, he said that in a few mines with which he was well acquainted the output had fallen since 1914 by 73 tons per native per annum, entailing, for an equal tonnage, the employment of an additional 5,600 natives or, on the basis of the 1914 output per native, a loss of 950,000 tons per annum. The following additional information as to labour cost per ton in the case of those same mines is instructive:—

	1914.	1919.	Increase.
	s. d.	*s. d.*	*s. d.*
Whites	4 4	7 6	3 2
Natives	4 0	6 1	2 1
Total	8 4	13 7	5 3

The following is an analysis of the above increase in labour cost per ton:—

	Due to Higher Wages.	Due to Lower Average Output per Man.	Total.
	s. d.	*s. d.*	*s. d.*
Whites	1 1	2 1	3 2
Natives	0 3	1 10	2 1
	1 4	3 11	5 3
	= 25·4 per cent.	= 74·6 per cent.	

The figures apply to a few mines having an output of approximately 2,500,000 tons per annum, so that the 5*s.* 3*d.* per ton increase in labour cost alone is accountable for a loss on this tonnage at the rate of 656,000*l.* per annum, of which 75 per cent., or 492,000*l.*, represents the loss from decreased average output per man.

From the same cause, lower output per man, the increased cost per ton in other directions also amounts to a great sum annually. For example, if each miner with his complement of labour and equipment broke 5 tons of ore more or less per day, the total cost of mine and plant maintenance, mine supplies, supervision, general charges and so forth, would not be much affected, but the cost per ton under these headings would alter very materially.

We read in *The Iron Age* that as an immediate means for correcting present abnormal commodity prices and reducing the period of excessive war department taxation, resolutions unanimously adopted by the board of directors of the National Association of Manufacturers at a meeting in the general offices in New York, on Friday, July 18, urge public support of an effort greatly to increase the industrial production of the country, pointing out the growing tendency to restrict production on the theory that the less work a man does the more work he provides for others to do.

The resolutions declare that much of the industrial antagonism which exists between employers and employees is based on the unjustifiable and systematically fostered belief among the people that the manufacturers of the country are mainly responsible for the levels which prices generally have attained. Attention is also called to the fact that heavy war department taxation has contributed heavily to present high prices, and increased productiveness is described as an effective means of shortening the duration of war tax burdens now imposed on the American industries and the individual American citizen.

Factory workers are called upon to lend their aid to the manufacturers, to the end that factory production may be immediately increased, as a way of restoring reasonable and more normal price conditions. Legislative authorities, the press, the churches and educational institutions are also urged to give their co-operation to the movement for increased production as a means of relieving oppressive and economically unjustified present living conditions.

The French daily press states that bricklayers and masons in the centre of France complain of competition on the part of coal miners. The latter, when their eight-hour day in the pits is completed, take up jobs with contractors in the same town and put in with them as much as 4 hours' work. This does not suit the bricklayers and masons who, it is stated, "express their astonishment at this unforeseen consequence of the 8-hour day Act." But the Act, the French press adds, has not prohibited workmen from employing their own free time in the way they think fit—they can even work in their own free time if they so choose.

RECONSTRUCTION IN FRANCE.—The Vulcan Steel Company, New York, says *La Democratie Nouvelle*, is to undertake reconstruction in the devastated region of Nancy. A total expenditure of 1,250,000,000 francs is referred to in the contract, applicable to bridges, public buildings, works, churches, &c. It is thought likely that the expenditure will even exceed the above figure. The works are deferred owing to the rate of exchange being at present unfavourable to France. They are to be paid by bonds guaranteed by the German indemnity.

SHANGHAI SHIPBUILDING AND TRAMWAYS.—We read in *The London and China Telegraph* that a new shipbuilding company has been formed at Shanghai, the Sung Fuh Yue Shipbuilding Company. It has secured 15 acres of land, on which it is proposed to build a plant capable of turning out large vessels. It is reported that this concern has the backing of Japanese interests. The Shanghai Tramways Company (British) has decided to build its own street (tram) cars. The company has acquired an acre of land, on which it will build the new factory building and instal the required machinery. Orders for the machinery have not as yet been placed. The company proposes to begin its building operations with the construction of 15 street cars and 7 cars for use in connection with its rail-less operations.

TEMPERATURE GRADIENTS IN OIL WELLS.—From figures disclosed by C. E. van Orstrand when lecturing before the Geological Society at Washington recently the rise of temperature in the deep wells of Texas, Oklahoma, Pennsylvania and Western Virginia is less regular and uniform than might be expected. The wells extend to depths of 7,000 ft., and the temperature measurements are supposed to be exact within 0·5 deg. F. or, at the extreme depths, at least within 0·5 deg. F. There is a general increase in the rise of temperature as greater depths are reached. In the Golf Well, the gradient is 1 deg. in 97·5 ft. near the surface, and as much as 1 deg. in 46·5 ft. between 6,000 ft. and 7,000 ft. But temperatures observed at the same depths in Texas and Oklahoma differ widely from those observed at the same depth in the more northern fields. In two wells, near Mannington, West Virginia, the oil had a temperature of 93·2 deg. F. at 2,900 ft.; at Ranger, in Texas, five wells gave oil at a temperature of 135 deg. F. at 3,400 ft., which is a much higher figure. The average rate of increase near the surface was found to be 1 deg. F. in 51·5 ft. in 13 wells of Texas and Oklahoma, but only 1 deg. in 91·5 ft. in Virginia and Pennsylvania.

UNITED STATES SCREW THREAD COMMISSION.—The National Screw Thread Commission, says *The Iron Age*, sailed for Brest, from Hoboken, N.J., on the Leviathan, on July 13. The delegation consisted of Dr. S. W. Stratton, chairman; Lieutenant-Colonel E. C. Peck, vice-chairman, representative of the United States Army; Captain John O. Johnson, representative of the United States Army. Commander L. B. McBride, representative of the United States Navy, at present attached to the American Embassy, London; F. O. Wells, representative of the American Society of Mechanical Engineers; Luther D. Burlingame, representative of the A.S.M.E., alternate for James Hartness; H. L. Horning, representative of the Society of Automotive Engineers, alternate for E. H. Ehrman; Captain Earle Buckingham, representative of the S.A.E., alternate for H. T. Herr; and H. W. Bearce and Lieutenant Robert Lacy, technical secretaries. The party will meet French engineers in Paris and then proceed to London, where arrangements have been made for an informal conference with the British Engineering Standards Association. It is expected that a tentative agreement will be reached with the British on pipe thread standards.

AN HISTORIC POWER STATION.

Fig. 1.

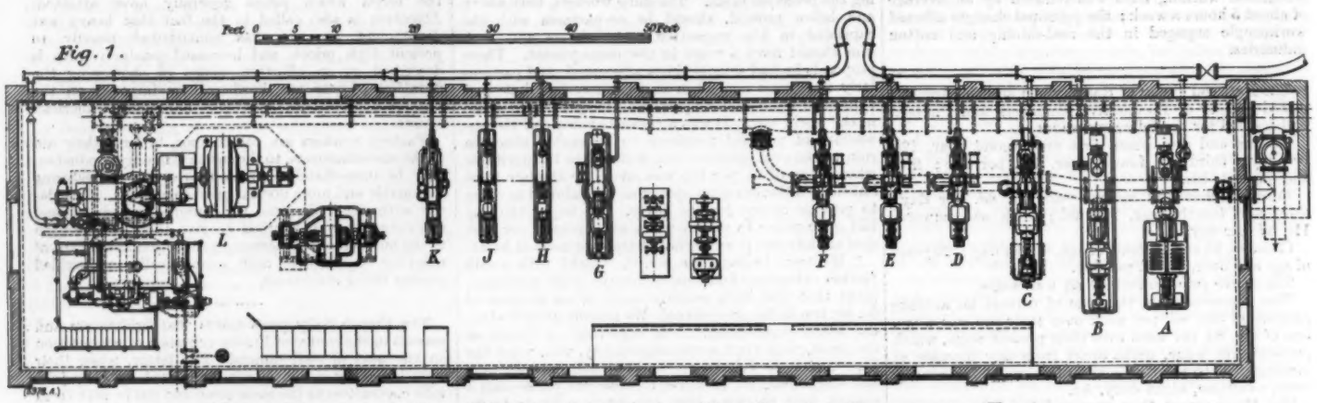


Fig. 1. Plan of the Power Station at the Ackton Hall Colliery, Featherstone, Yorkshire.

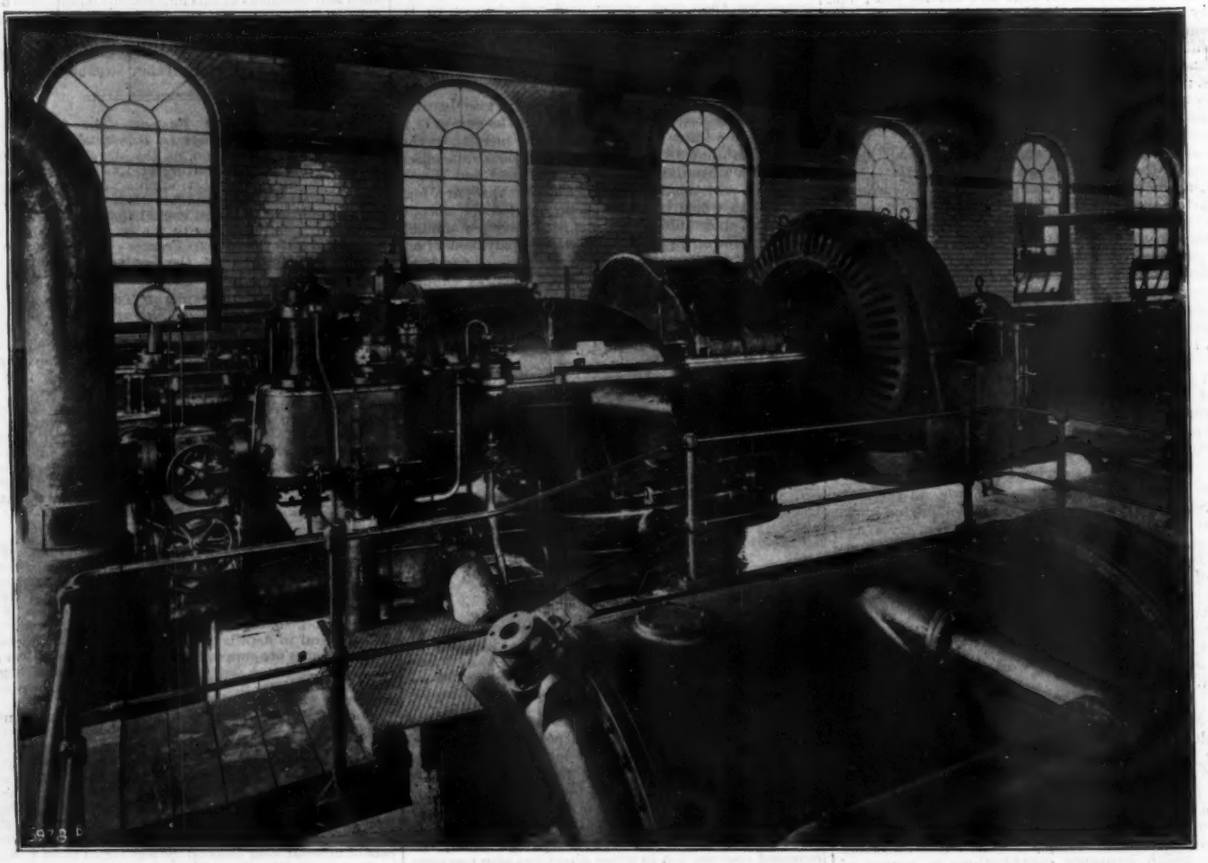


Fig. 2. 1000-Kw. Parsons Turbine with Gearing and Alternator; Messrs. C. A. Parsons and Co., Ltd., Heaton, Newcastle-on-Tyne.

Numerous articles have appeared in this and other journals illustrating the latest type of power station equipped with steam turbines of recent design and large capacity. The power station now described does not contain individual machines of large size, but is of considerable interest historically in that it presents a panorama of the development of the steam turbine as applied to the driving of dynamos generating electricity for colliery purposes. In the same station there are turbo-generators of earliest design as well as of the very latest type. The station referred to is at the Ackton Hall Colliery, Featherstone, Yorkshire, and has been developed from the commencement under the supervision of Mr. Roslyn Holiday, colliery agent to Lord Masham.

The first Lord Masham who, prior to being raised to the peerage, was world-widely known as Samuel Cunliffe Lister, founder of Manningham Mills, and a great inventor of textile machinery, acquired the Ackton Hall Colliery in 1891 and immediately applied his exceptional ability to its development on progressive lines, being the first in this country to install coal washing plant driven by electric motors—incidentally, the same motor driven coal washing plant, of the "Luhrig" type, is still in regular and satisfactory operation. He applied electrical driving to underground haulage, and to most of the surface machinery, with the exception of winding and ventilating; the latter is now in contemplation. He was a pioneer in electrical coal cutting, in which he was keenly interested, and designed, built and applied various experimental machines on the coal face. Mr. Roslyn Holiday, who was at that time the electrical engineer, was associated with the late Lord Masham in all these early applications of electric power to colliery working. He succeeded his father, the late Mr. Alfred Holiday, as colliery agent, but still takes a very active interest in the electrical equipment.

All the electric generating plant on the colliery for many years past has consisted of steam turbo dynamos of the "reaction" type, being built by Messrs. C. A. Parsons and Co., Limited, of Newcastle-on-Tyne—the first two of which, each of 150 kw. rating at 500 volt direct current, were constructed in 1895, and are still in commission. A third similar set was added in 1898. Owing to the shortage of cooling water, all the earlier sets work non-condensing; for the recent plant, however, two large concrete reservoirs have been constructed and fitted with cooling sprays thereby securing the greater economy resulting from condensing the exhaust steam. The original electric power-house was dismantled about eleven years ago and a new one built of much larger dimensions to which, with the exception of some small sets, the turbo generators have been transferred.

A plan of this new power station is shown in Fig. 1., and a view of the latest addition to the turbo plant in Fig. 2. Figs. 3 and 4, on page 246, are perspective views taken from opposite ends of the engine-room. In the plan view of the station the various machines are

indicated by letters, and particulars of each of these sets are given in the subjoined table :—

Ref. Letter.	Kw.	Particulars.	Date Constructed.	Age.
				years.
A	300	500 volts, direct current..	1909	10
B	300	500 volts, direct current..	1901	18
C	150	350 volts, three-phase ..	1901	18
D	150	500 volts, direct-current..	1895	24
E	150	500 volts, direct current..	1899	20
F	150	500 volts, direct current..	1895	24
G	60	110 volts, direct current..	1909	10
H	44	110 volts, direct current..	1901	18
J	44	110 volts, direct current..	1897	22
K	32	110 volts, direct current..	1897	22
L	1,000	3,300 volts, three-phase ..	1918	1¼

It is of considerable historic interest to note the particulars of these machines, all of which are still fit for useful work. Plant A is a 300-kw., 500-volt direct-current machine. The dynamo of this set was the first turbine-driven direct-current dynamo built and equipped with Messrs. C. A. Parsons' compensating windings. This dynamo was on exhibition at Heaton Works for a few years until the merits of this well-known method of compensating windings had been demonstrated, when it was sold to the Ackton Hall Colliery Company. Plant B is also a 300-kw. direct-current machine at 500 volts, built in 1901, but not fitted with compensating windings.

Plant C on the plan was constructed in the year 1900, and was the first three-phase turbo-alternator built in England, and probably the first in the world. It was installed to provide current for driving coal-cutting machines. We believe the Ackton Hall Colliery was the first in this country to use three-phase power for coal-cutting. The alternator is of the revolving armature type and supplies three-phase current at 350 volts and a frequency of 42 cycles per second.

Plants D, E and F are the first 500-volt direct-current turbo-generators ever built and adapted to power purposes. As previously mentioned, two of them were constructed in the year 1895, and the third in the year 1898. The turbines are of the parallel-flow reaction type, whilst the dynamos are interesting in being equipped with gramme-ring armatures and fire-proof insulation enabling them to run at temperatures higher than were usual at that time.

Included in the other plants shown is one mounted immediately on its own surface condenser, which serves as a bedplate, the condenser pumps being driven from the turbine. A similar set is at the Lord Masham's Ackworth Colliery. There are also two small turbo-dynamos at 110 volts used for lighting purposes—the first of which was installed in 1897.

Coming now to the last plant erected, we have a further interesting development in the use of the steam turbine. The periodicity of 42 per second was adopted by the Ackton Hall Colliery Co., for their coal cutter motors. The majority of the motors on the colliery are 500 volts direct-current, but under the new regulations all motors underground have now to be alternating current, and the present is a transition stage from direct current to alternating current. It is intended that in future, all small motors shall operate at 500 volts alternating current, and the large motors 3,300 volts alternating current, at 40 cycles per second.

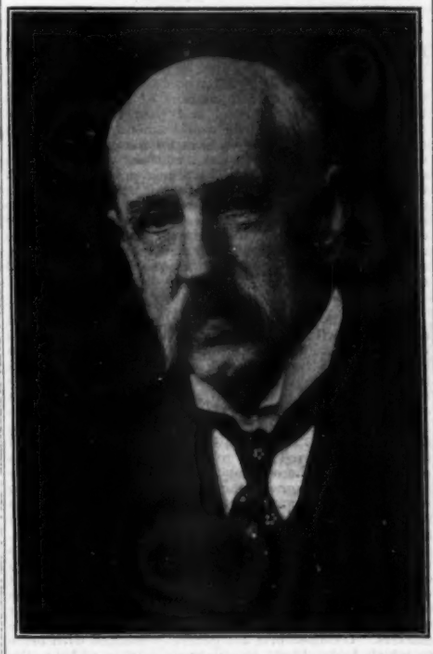
In 1916 extensions to the three-phase generator plant were required, and as the highest speed permitted by a 40 period alternator is 2,400 r.p.m. it would not have been practicable to install a direct coupled turbo-alternator for that speed and the size required, and at the same time to secure the maximum efficiency. It was decided, therefore, by the engineers responsible to adopt reduction gearing between the turbine and the alternator so enabling the turbine to be run at the efficient speed of 4,000 r.p.m., and the alternator at 400 r.p.m. This has the further advantage at a colliery of dispensing with the necessity of air filtering apparatus, as the slow speed alternator is of the open type with ample air spaces.

The plant installed is that marked "L" on the block plan and shown also in Fig. 2. The turbine is of the Parsons' mixed pressure type, supplied with low-pressure steam at 16 lb. per square inch absolute and with high pressure steam at 110 lb. per square inch above atmosphere. The reduction gearing is of the Parsons' patented "creep-cut" type, having a ratio of 10 tolerances. The alternator is of the open type, and was supplied by Messrs. the Phœnix Dynamo Manufacturing Company, Limited. The surface condenser is by Messrs. Cole, Marchant and Morley, Limited, and is provided with turbine-driven circulating and air pumps made by Messrs. the Rees Roturbo Company, Limited. The official trials of the geared turbo alternator were in every way satisfactory, including the steam consumption, the guaranteed figures of which were comfortably obtained.

Mr. J. A. McLay of Leeds, has collaborated with Mr. Roslyn Holiday, in connection with the installation of the most recent plant, including the condensing and water-cooling arrangements, and his able and careful attention to detail has no doubt contributed largely to the highly satisfactory and efficient results obtained. No less than four of the plants may be described as having been pioneer machines at the time they were installed, so that very great credit is due to the engineers concerned for the persistent way in which they have kept in the foreground of progress in respect of their generating machinery, whilst at the same time they have maintained in efficient running condition the older types of plant originally installed.

THE LATE MR. ROBERT BATSON JOYNER.

We regret to have to record the death, which occurred at Poona, India, on the 30th ultimo, of Mr. Robert Batson Joyner, C.I.E., M.Inst.C.E., whose name will be best remembered in connection with the Tata hydro-electric works for supplying power to the Bombay cotton mills. Mr. Joyner was the designer of this work and superintended its construction as hydraulic consulting engineer. The subject of our memoir, whose portrait we reproduce herewith, was born at Chadwell St. Mary, Essex, on March 1, 1844, so that, at the time of his death, he had attained the ripe age of 75 years. He was educated privately, and



after being employed for some five and a-half years on railway, water and sewage works in this country, he joined the Bombay Public Works Department in 1868, in which service he remained for 30 years and eventually attained the rank of superintending engineer. During this period he was engaged almost entirely in hydraulic engineering work, being connected with most undertakings of this class in the Bombay Presidency. His early work included the calculations for the stability and the construction of the Lake Fife dam at Khadakwasla, under Colonel Fife, the design and construction of the Mutha Right Bank Canal, and the construction of the Poona Water Works. During the great famine of 1876–78 he was in charge of some 60,000 labourers engaged in the construction of several large irrigation dams, for which work he was specially thanked by the Government. By special permission of the Viceroy his services were lent to the Gokak Water Power Company for the purpose of designing and constructing works to utilise the falls of the Ghatprabha at Gokak. This work, which was probably the first of its kind in India, was one of exceptional difficulty owing to its isolated position. The whole of the design and construction work was, however, completed by Mr. Joyner in 19 months, and the plant has now been in successful operation for upwards of 30 years. In 1889 Mr. Joyner was sent by the Government to Sind, to consider the irrigation difficulties on the left bank of the Indus, and, as a result of his investigations, he prepared an exhaustive report containing proposals for a number of works to improve the river and protect an area of 6,000 sq. miles. At that time, however, the cost of the works was regarded as prohibitive, and the proposals were not carried out, but some 10 years later a number of Mr. Joyner's suggestions were adopted. The value of his work in this connection was publicly acknowledged at the opening of the Jamrao canal in 1899 by His Excellency the Governor, who stated that Mr. Joyner's persistent advocacy of his canals project had led to the investigation of Sind matters generally, and, among other things, had led to the construction of that canal.

After his retirement from Government service in 1898, when he was decorated by Queen Victoria as a Companion of the Indian Empire, Mr. Joyner devoted all his talent and experience to the development of hydraulic power in Bombay and other Presidencies. His most important work, however, was done in connection with the Tata hydro-electric works, above referred to. The success of the whole of this scheme, of which a full account was given in ENGINEERING, vol. xcvi., on pages 547 and 578, depended mainly on the question as to whether the Ghat rainfall would supply sufficient water to generate the power required. Mr. Joyner accordingly carried out an exhaustive research into the character of the Western Ghat rainfall, and from the results of his investigations he was able to satisfy the promoters that the scheme was both technically and commercially feasible. The information as to rainfall thus obtained is of considerable importance, and will undoubtedly prove of great value to engineers in the future. Mr. Joyner read a paper entitled "The Tata Hydro-Electric Power Supply Works, Bombay," before the Institution of Civil Engineers, as recently as February last, and for this paper he was awarded the Telford medal and an Indian premium.

By all who knew him personally Mr. Joyner will be remembered best as a staunch and true friend, while those who know only of his work will rightfully regard him as an eminent Indian engineer.

A SUGGESTED BRITISH EMPIRE PATENT LAW.

*Report of Committee of the Institution of Electrical Engineers on Patent Law Amendment.**

NUMEROUS schemes for enabling patent protection to be secured expeditiously and at a reasonable cost in the whole or in certain parts of the British Empire by means of a single patent have been proposed from time to time, but most of these, though at first sight apparently sound and likely to be beneficial, have the serious practical drawback that to make them effective would involve radical changes in the existing statute laws of the different parts of the Empire.

The scheme outlined in this report aims at carrying out what should be the main objects of any Empire patent law, viz. :—

1. Low cost.
2. Ease of application throughout the Empire.
3. Reciprocity.
4. No change involved in the existing laws of the Empire.
5. Adherence to the scheme optional by any Dominion.

Under this scheme any person may obtain an Empire patent covering as many of the British Dominions, Colonies, Dependencies and Protectorates (collectively referred to in this report, for convenience, as territories), as he may select, by making application to the British Patent Office. The fees payable will be the sum of the existing local Government fees in the selected territories, plus such small fee as may be charged by the British Patent Office to cover the expense of carrying out its part of the scheme. The application will be examined and the patent granted in the same way as is an application for a British patent, and the specification when printed will bear the names of the selected territories in which it is effective. Thereafter the patent will be assimilated with the domestic patents in each of the selected territories and will be subject to the local laws in such territories for the determination of validity, infringement and all other questions affecting Letters Patent after grant.

In the Appendix will be found a list of the 48 Dominions, Colonies, Dependencies and Protectorates of the Empire which have their own separate enactments for granting patents.

It is clearly desirable in the interests of inventors and of the public and industry generally that the cost and trouble of securing patent protection throughout the Empire should be materially reduced.

Careful consideration has been given to the suggestion that a patent should be obtainable covering the whole of the British Empire in the same way that a patent in the United States covers all the States in the Union, but there are so many difficulties connected with such a scheme that it is not felt any practical result can be expected of any attempt to elaborate a proposal along such lines. It is believed that the present scheme is practical and has the merit that it can easily and immediately be put into operation without disturbing the existing laws in the various territories in the Empire.

It is assumed that usually an inventor will apply for a patent first in that part of the Empire in which he is domiciled or has his business or manufacturing establishment, in order to secure without delay protection for his invention, and it is not proposed that

* This report was adopted by the Council of the Institution of Electrical Engineers on July 14 last.

the existing Patents Acts or Ordinances in the various parts of the Empire should in any way be disturbed. (This, however, does not mean that the Governments of the various Dominions, &c., should not be urged to amend their laws so that they may all be made as uniform as possible in at least their principal provisions).

The scheme proposes that in each territory a short Act or Ordinance should be passed to the effect that any Empire patent which has been made applicable to such territory shall be received and treated by it in all respects as though such patent were a patent which had been granted under the territorial Patent Law. This is important, for otherwise there would exist two classes of patents, and difficulties might arise in interpreting them in the courts and elsewhere. The fact that the form of the specification and claims of the Empire patent might differ somewhat from that of the domestic patent should not give rise to any practical difficulties.

It is obvious that such an Empire patent as is proposed, in order to secure uniformity, which is essential, must be issued from one centre, and that centre it is suggested should be the British Patent Office.

It is recommended that the Empire patent should be applied for and issued in the same way as a British patent. Where a British patent has been applied for or obtained, the Empire patent will be a duplicate of it.

An applicant residing in any part of the British Empire may apply for a patent either in his own Dominion (being a Dominion granting a patent) or in any other part of the Empire granting a patent, and shall have a sufficient period—eighteen months is suggested—from the date of his first application in any part of the Empire in which to apply for an Empire patent. An Empire patent if applied for within such period shall have a priority date as of the date of application for the corresponding patent first filed in any part of the Empire.

This provision should not give rise to any difficulties, as the practice would follow that of applications for patents under the International Convention, which gives a period of one year within which applications may be filed in any of the countries belonging to the Convention.

To carry out the scheme it would be desirable to establish an Empire Patent Department of the Patent Office in London, in which all applications for Empire patents would be filed and the appropriate fees paid in respect of the selected parts of the Empire. To this department would also be paid at the appropriate times such renewal fees as may be necessary for keeping the Empire patent in force in such parts of the Empire as the patentee desired to maintain the patent. The Empire Patent Department would transmit through the appropriate channels the fees received and due to each of the Dominions, &c., in respect of the Empire patents issued and also the renewal fees, if any, paid on such patents to keep them in force.

It is urged that whilst it would be highly desirable for all parts of the Empire to adhere to this scheme for an Empire patent from the outset, it is not necessary that the adoption of the scheme should be delayed until this has been achieved. Valuable progress would result if certain parts only of the Empire decided to adopt it at first and power were given to other parts of the Empire to adhere to the scheme at a later date.

It is strongly recommended that the Empire patent should rest on its own foundation in each part of the Empire. This naturally follows from the suggestion that the Empire patent should be assimilated with the domestic patents in the various parts of the Empire, and read and interpreted in accordance with the law and practice obtaining in each part of the Empire. If, for example, in an infringement or revocation action or like proceeding in the United Kingdom or in any Dominion, the patent were declared invalid, this should not affect its validity in another Dominion in which the validity of the patent was not attacked or in which such an attack failed owing to the circumstances being different. These are substantially the conditions which obtain at present in respect of the separate patents issued by the various Dominions.

As to the fees payable in respect of the Empire patent, it would be very desirable for the various Dominions to agree on a scale of reasonable fees to be payable on application for a patent and at uniform times for the renewal of the same during its term. It is realised that the fees payable at present in respect of both these conditions vary considerably in the different Dominions, in some of them being very reasonable and in others inordinately high, and that the amount of fees payable do not in some cases correspond in amount with the extent of the territory covered or the volume of the trade in a patented article which may reasonably be expected to be done in connection therewith. However, for the same reasons that the establishment of an Empire patent has been advocated along the lines contained in this report, and in order that objections to the early commencement of the scheme may not be raised by the various parts of the Empire on the ground of loss of revenue, it is suggested that the fees payable in any of the Empire territories should remain as they are at present. It is believed, however, that the reduction in fees which is recommended would be more than made up in the total amount received by the greatly increased number of patents applied for in the various Dominions under the present scheme.

It might be suggested that if the fees in the various Dominions are not reduced no great reduction in the cost of protecting an invention by patent in the Empire under this scheme would result. This, however, is not so, as the cost at present is not so much due to the Government fees payable as to the expenditure necessary in preparing, filing and prosecuting an application for a patent separately in each of the Dominions.

W. M. Mordey,
Chairman of the Committee.

June 21, 1919.

APPENDIX.

Empire Dominions, &c., having their own Separate Enactments for Granting Patents.

Australian Commonwealth.	Johapur.
Bahama Islands.	Johore.
Barbados.	Kedah.
Bermuda.	Kelantan.
British Guiana.	Leeward Islands.
British Honduras.	Malta.
British Solomon Islands Protectorate.	Mauritius.
	Mysore.
Canada.	Newfoundland.
Ceylon.	New Zealand.
East African Protectorate.	North Borneo.
Egypt.	Nigeria.
Falkland Islands.	Nyassaland Protectorate.
Federated Malay States.	Rhodesia (Southern).
Fiji.	St. Helena.
Gambia.	St. Lucia.
Gibraltar.	St. Vincent.
Gilbert and Ellis Islands Colony.	Seychelles Islands.
	Sierra Leone.
Gold Coast Colony.	South Africa (Union of).
Grenada.	Straits Settlement.
Kong-Kong.	Travancore.
Hyderabad.	Trinidad and Tobago.
India.	Uganda Protectorate.
Jamaica.	Zanzibar.

Foreign Patents in the United States.—We read in *The Iron Age*, New York, that the advocates of a compulsory working provision in the patent laws of the United States are calling attention anew to the injustice of the privilege accorded citizens of foreign countries to patent inventions there, and then to permit these to lie unused. Those who would amend the law, point to the organised action of German manufacturers preceding the war, in using the American patent laws to secure control of the market for those products in which they specialised. They see no reason why, if conditions remain unchanged, the Germans will not continue the same methods, and they believe manufacturers of other countries, meanwhile, would avail themselves of the opportunity to an extent they never attempted before, since the successful results of the system have been well advertised.

Innovations in the Metallurgy of Lead.—In conjunction with the University of Utah and with various mining companies, the United States Bureau of Mines has since 1914 been carrying on extensive experiments for the purpose of the better utilisation of the ore treasures of the State of Utah. A detailed account of the researches on the low-grade lead ore is given in Bulletin 157 of the Bureau, a paper of 169 pages drawn up by Dorsey A. Lyon and Oliver C. Ralston. Most of the processes tried are modifications of well-known processes; but there is much scope for variety in their application, and some of the innovations, also in roasting furnaces, are of considerable interest. Some novelties in flotation are also noteworthy. Thus the lead can most profitably be recovered from bleached ores by electrolysis, and chloridising roasting at higher temperatures than usually recommended, followed by electric precipitation of the metallic fumes, looks promising. The ores dealt with may be classified as carbonates and more or less oxidised ores, sulphides and slimes; gold and silver may be present, and their recovery will complicate matters. Oxidised ores are generally leached with brine to which hydrochloric or sulphuric acid is added; the chloride solution is precipitated with lime or electrolysed, and it was found that the electrolysis with iron anodes answered very well, especially in impure solutions, by currents of less than 1 volt and of high density, 40 amperes per square foot, the current efficiency then rising above 90 per cent. The spongy lead produced oxidises rapidly, but when compressed it can easily be smelted and freed of iron dross. Silver in the electrolytic bath is subsequently precipitated by lime or better by scrap iron. If not present as chloride, the silver would not pass into solution; such ores are submitted to chloridising roasting by the old Augustin process; the name is not Augustine, by the way, as spelt in the Bulletin; Augustin was a miner in the Mansfeld copper-schist district seventy years ago, at Eisleben. For that roasting both pyrite and salt should be added to the ore and coal. In Utah the roasting was effected in new furnaces of Holt-Dern or Christensen. When the temperature is kept at about 700 deg. C., little lead is volatilised, and this lead can be recovered by the electric dust-precipitation process of Cottrell. For mixed sulphides the temperature may purposely be raised, and the metal fumes be precipitated. In the presence of zinc sulphide, however, copper, silver, and gold are retained with the zinc, and are not volatilised; the iron is converted into oxide, and the lead volatilises. The calcium chloride from the furnace slag can be used for further chloridising roasting in the place of sodium chloride. Some carbonate ores slime badly; these slimes can be concentrated by flotation after superficial sulphidising, which is best effected by means of sodium sulphide, as the experiments show; sulphuretted hydrogen is too much of a nuisance. The silver and gold rise with the lead. Whether flotation is on the whole practicable depends upon transport and water facilities and other general features, of course. The treatment of mixed sulphides containing zinc remains a rather difficult problem.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—Little change falls to be reported in the ruling conditions in the Scotch steel trade, and makers' books are still well filled. With the shipbuilding and general engineering trades all well placed for business at the present time there is an all-round demand for material, and steel manufacturers are being pressed for deliveries of stuff on order. Plate mills are turning out a fairly large tonnage, and no delay is taking place in hurrying it to consumers, whose needs it seems impossible at times to satisfy. For sectional material the demand is not so good, and producers are quite able to keep abreast of their orders, and in this department there is no delay in deliveries. Black sheet makers have a fair amount of work on hand, but the advance in price has caused a slight check in the flow of new business. Most of the work passing in the different branches of the steel trade is on home account and the export side of the industry is being neglected to some extent, as very little is being done in that direction just now. The loss of some of the foreign markets is certainly not relished by the trade, but there is something to be said on behalf of the home buyer whose requirements must be met. An increased output would seem to be about the only solution, and if our workers in all branches of industry could only realise this, and give us a slightly higher tonnage per shift, then there would be little fear for the future. Prices show no change and continue very firm.

Malleable Iron Trade.—The West of Scotland malleable iron makers keep busy, but with prices on so high a level there seems little inclination on the part of buyers to purchase otherwise than very sparingly. A moderate amount of fresh business is going through, but orders on hand are sufficient to ensure steady running for the present. The home price for "crown" bars is firm at 21*l.* 12*s.* 6*d.* per ton, net, Glasgow. Export is quiet.

Scotch Pig-Iron Trade.—No falling-off has taken place in the demand for Scotch pig-iron, and makers are constantly being pressed for deliveries. Consumers are so busy that short deliveries hamper them very much. The present enormously high price to which iron has soared has so far had little effect on business, but no buying ahead is taking place and only the more immediate requirements are being considered at all. Deliveries of the raw ore are rather better, but export is on a small scale. Hematite is still short and in great demand, but forge iron is more plentiful.

Educational Grants for Ex-Service Men.—Under the Government scheme of financial assistance for the higher education of ex-service officers and men, the total number of grants awarded by the Board of Education now amounts to 5,400, including officers and men in about equal proportions. The courses in respect of which grants have been awarded include more than 1,000 for engineering and technological subjects, between 600 and 700 for classics, philosophy and literature, and about an equal number for pure science and mathematics. Applications are still being received in large numbers and are being dealt with at the rate of more than 200 a day.

Silica Refractories.—In Technical Paper No. 116 of the United States Bureau of Standards, Donald W. Ross arrives at the conclusion that, to prevent spalling, bricks should be kept between 1,250 deg. and 1,350 deg. C. for a long time, and gradually be raised to higher temperatures subsequently. Continuing the work of C. N. Fenner and of Spotts McDowell, at the Geophysical Laboratory and the Bureau, Ross investigated the changes in volume, porosity, specific gravity and crystal form of the raw materials and of the leading commercial brands of silica bricks. Impervious, highly metamorphosed quartzites of tightly-interlocking grains seem to give better bricks than porous quartzites with rounded grains. The true specific gravity of a silica brick, he considers, is a direct measure of the degree to which the brick has been burned, and from gravity and porosity the subsequent expansion of the brick can roughly be predicted. Other investigators are rather doubtful about this estimate.

Metal-Corrosion by Calcium-Chloride Solution.—The use of an aqueous solution of calcium chloride as a non-freezing cooling liquid for motor vehicles has been advocated in the United States. In the *Journal of Industrial and Engineering Chemistry* of July last, P. Rudnik describes some corrosion tests to which he submitted three such commercial products. Of these solutions one was distinctly alkaline, the second neutral and the third acid. The tests were conducted by suspending plates of metal in the solutions, the metals tested being aluminium, copper and iron; the plates were suspended from copper wires, either singly or in pairs, or all three together; galvanic action was favoured in some of the tests, if not in all. Brass should surely have been tested as well, since radiator pipes are generally made of brass. All the plates were attacked by the $CaCl_2$, the aluminium most, the copper least; the corrosion became in all cases more pronounced after the plates had been immersed for about 18 or 20 days.—the whole test lasted 28 days. The increased corrosion after 18 days is interesting in so far as the conditions of sale of one of the solutions specified that payment should be made if no damage had been done to the metal within a fortnight; within that period the sellers offered to pay for repairs. Obviously calcium chloride solution is not a suitable cooling liquid, and the addition of formaldehyde which had been made in one case, does not improve it. The solutions contained about 30 per cent. of calcium chloride and up to 3 per cent. of magnesium chloride.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Seven to 14 days must elapse before the South Yorkshire iron and steel industries are able to resume normal production. Though an appearance of partial activity has been maintained during the coal strike month, actually very little steel has been produced or submitted to heavy processes preparatory to manufacture. Forges, foundries and rolling mills have suffered the most severely, and if a normal supply of fuel were now available, these departments would not be in a position to reopen generally. Much plant and machinery has been set down for repair and overhauling and cannot be ready for at least a week. The process of resumption will be gradual, and as manufacturers and workmen are tired of enforced idling, the minimum amount of delay will be incurred. While it would be impossible to estimate in round figures the loss in steel output or in export trade due to the coal stoppage, there is no doubt that the South Yorkshire industries have sustained a severe blow from which they cannot immediately recover. Instances are widespread of manufacturers having been compelled to refuse orders owing to the uncertain outlook and the impossibility of guaranteeing delivery, and although a more hopeful spirit is the more general, it is feared in responsible quarters that some of the business so lost will be extremely difficult to recover, while a minor proportion of it will never return. Meanwhile, the gross volume of orders awaiting attention is substantial and augurs a busy period for most of the trade sections, heavy and light. Most tool-makers, excepting those dealing exclusively in high-speed and other special steels, report that they can keep their works fully employed until the end of the year on current bookings. The recent rush of orders has by no means ceased, though there are indications of diminished pressure on twist drills and agricultural implement parts. The extension of the allotment garden system has been responsible for a larger call for gardening tools. Another marked improvement is in light castings for building purposes. Local foundries are badly in arrear with orders. The pig-iron position is unchanged. The output of local blast furnaces when working at full pressure is barely equal to steel makers' requirements, owing to the wider extension of steel-making plant. Bar iron is in much the same position. If there is no improvement users will be compelled to supplement supplies from more distant sources.

South Yorkshire Coal Trade.—The strike in South Yorkshire is officially ended. At a conference here, arrangements were adopted for the resumption of work at the earliest possible moment, and to prevent any hitch arising, the management and men's representative of every colliery branch have each been given a copy of the terms of settlement and the new working conditions. Production has already been resumed on a restricted scale. Where actual coal getting is impracticable on account of the damage done by water and falls, the miners are working under pressure to complete repairs. The damage is extensive, however, and a full supply cannot be available for at least another week. The only satisfactory feature of the position is that the good relations between the South Yorkshire owners and the miners are unimpaired. The men realise that the owners, although willing to make superior concessions, were compelled to carry out the Coal Controller's instructions. Quotations:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.* Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.* 6*d.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NON-FERROUS MINING.—The President of the Board of Trade has appointed a Departmental Committee to investigate and report upon the present position and economic possibilities of non-ferrous mining in the United Kingdom, and to make recommendations as to such Government action as may be expedient in regard thereto. The members of the committee are Mr. H. B. Betterton, M.P. (chairman), Mr. H. F. Collins, Mr. J. Harris, Dr. F. H. Hatch, Sir Lionel Phillips, Bart., Mr. R. A. Thomas, and Mr. James Wignall. All communications should be addressed to the Secretary, Mr. W. Palmer, Gwydyr House, Whitehall, S.W. 1.

BUSINESS FACILITIES AT ATHENS EXHIBITION.—The Federation of British Industries state that in order to facilitate the conduct of business by exhibitors, and by Greek buyers attending the Athens Exhibition, a number of banks and other establishments will be directly represented at the Zappeion. Several offices will be fitted up in which banking, shipping, agency, insurance and similar business can be transacted on the spot. The British Trade Corporation will be found in the hall immediately to the left of the main entrance. Here they will have an office where banking transactions can be carried out, inquiries and arrangements made with regard to credits and their insurance, &c. The Ionian Bank will be similarly represented. Their branch in the Zappeion will be a great convenience to exhibitors, who will thereby be saved any loss of time which might otherwise be incurred in continual journeys to and from the chief office in the town. Messrs. Furness Withy and Co. and the Cunard Steamship Company, Limited, will have offices in which shipping business can be done; also the Levant Company, where transactions relating to their agency and other business may be carried out; there will be similar facilities with regard to insurance, &c.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—With holiday-making general, there is little new ascertainable concerning Cleveland pig-iron. However, it may be taken that the trade position keeps firm and unchanged. Scarcity of Cleveland foundry iron continues pronounced, but this week's holiday stoppage by many of the local consuming works should release a little pig-iron for the market. Home requirements, however, promise to be heavy for some time. Inquiry from abroad is more active, and this month's shipments so far show improvement on the clearances for the corresponding period of July. Foreign trade would undoubtedly expand considerably if more of the descriptions of iron needed were obtainable. For home consumption No. 3 g.m.b. Cleveland pig-iron and No. 4 foundry are 160*s.*, No. 1 is 164*s.* and No. 4 forge not more than 157*s.*; and export rates are 5*s.* above these quotations.

Hematite Iron.—Producers of East Coast hematite are well placed, most of them having pretty full order books, but they are prepared to entertain forward inquiries. There is a moderate business passing on home account, but foreign trade is quiet, Nos. 1, 2 and 3 are 200*s.* for home use, and 205*s.* for export, and No. 1 is 202*s.* 6*d.* for home consumption and 207*s.* 6*d.* for shipment abroad.

Foreign Ore.—Transactions in foreign ore are very few. Consumers continue to hold aloof from the market. They are generally well bought, and have substantial imports coming regularly to hand in fulfilment of running contracts. Rubio, of 50 per cent. quality is round about 53*s.* 6*d.* c.i.f. Tees, and the freight Bilbao-Middlesbrough stands at 25*s.*

Coke.—Coke is scarce, and indeed the heavy home requirements are difficult to meet. Demand on behalf of Allies and neutrals is heavy. Medium blast-furnace kind is 48*s.* at the ovens, and low phosphorus sort 49*s.* 6*d.* at the ovens. For export patent oven coke is 85*s.* to 90*s.*; beehive, 90*s.*; and gas, 80*s.*

Manufactured Iron and Steel.—Most works are closed this week for the local race holidays. Producers report home contracts made that will keep them busily employed for a while, but when these are completed a period of slackness threatens as new business is by no means easily arranged, export negotiations are most difficult, prices rendered necessary by high cost of output being such as to make successful competition in foreign markets almost impossible. America and other countries are gradually capturing customers abroad who used to deal almost entirely with this district. Export quotations are not fixed, but are matter of individual negotiation. The following are among the principal market rates to home customers:—Common iron bars, 22*l.*; marked bars, 24*l.* 10*s.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel angles, 17*l.* 15*s.*; steel joists, 17*l.* 10*s.*; steel sheets, 20*l.* 5*s.* to 23*l.* 5*s.*; galvanised steel sheets, 24-gauge, 28*l.* 10*s.*; and heavy steel rails, 16*l.* 10*s.*

"THE EDGAR ALLEN NEWS."—We have received from Messrs. Edgar Allen and Co., Limited, Imperial Works, Sheffield, a copy of their journal, No. 1, for July last. The publication is destined to give technical and practical information upon the firm's steel and steel products, so as to obtain from these the most efficient service. Apart from various short articles and abstracts, the first issue contains data on file-making, on the characteristics of manganese steel, tungsten, &c.

CONTRACTS.—A contract recently awarded to the English Electric Company, Limited, by the Leicester Corporation, for their Aylestone Power Station, includes the supply of a 5,000-kw., 3,000 r.p.m. turbo-alternator set complete with condensing plant and circulating water piping, &c.; also rotary converters, transformers and E.H.T. switchgear and a complete boiler-house equipment, including, in the initial stages, two marine-type Babcock water-tube boilers, each to supply 50,000 lb. of steam per hour at 200 lb. pressure, superheated 250 deg.

BENZOLE FOR MOTOR CARS.—The Automobile Association has undertaken to provide a test which shall be at once positive and conclusive, to prove that benzole of good quality is a most satisfactory motor fuel. Arrangements are being made for a road test of 10,000 miles on a moderate-sized touring car. The test will be carried out under conditions which will preclude all possibility of criticism as to its genuineness and the finality of its results. The engine and all parts will be examined by an independent authority both before the test begins and immediately after its conclusion. The benzole used will be "N.B.A. Brand" of approved specification. This benzole is manufactured by the various producers who are members of the National Benzole Association, and samples will be taken constantly during the run for analysis by Dr. Harold Colman, who has acted during the war as referee on questions of benzole analyses for the Explosions Department of the Ministry of Munitions. Not only will samples of the fuel be analysed, but the lubricating oil taken from the engine will also be submitted to Dr. Colman for his report. The details of the test are being arranged by Captain R. H. Montgomery, the head of the Fuel Department of the Automobile Association, and secretary of the Joint Fuels Committee and the results will be certified by an independent observer or observers. Further information and particulars will be announced as soon as a new British car has been secured.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—That the workers in and about the mines should, under the new Government scheme, have directors representing them in each area group to which they belong, does not find favour with either the employers or employees. It is also feared that the miners will continue to use their power to bring about nationalisation and that a policy of "go easy" will be resorted to in respect to production, and this will have a paralysing effect on the coal trade. Already the decline in outputs has brought business to an almost complete stagnation, for production now is hardly sufficient to meet the home demands, and consequently the export trade is reduced to such a small volume that exporters experience much difficulty in making up even small cargoes and, after arranging for supplies with collieries, they are not sure of obtaining releases of the coals purchased from the authorities. An important Portuguese firm of importers has informed their Cardiff agents that they have decided not to purchase any more South Wales coals for the present in view of the fact that the Portuguese Government has not yet increased the price of coal. It is assumed that the maximum schedule prices in Portugal are too low to enable importers in that country from placing orders for South Wales coals at current local prices, coupled with the cost of freight and insurance. It will be recalled that during the strike of Yorkshire miners the Government commandeered coals intended for export abroad and diverted the cargoes to United Kingdom ports. The Coal Controller has now advised collieries that the maximum standard amount which can be charged for these coals is on the basis of the Price of Coal Limitation Act, which is 10*s.* above the pit-head prices for similar coals in 1913–14. The current price for these coals for export at the time of requisition was from 75*s.* to 80*s.* per ton for large and from 50*s.* to 65*s.* per ton for smalls, and exporters and colliery owners claim that on such cargoes the Controller should pay the current market prices. The question is being considered by the commercial section of the Monmouthshire and South Wales Coal Owners' Association. Meanwhile, new business is confined within extremely narrow limits, as the authorities continue to take large quantities for shipment to United Kingdom ports and for the coaling stations abroad. At the same time collieries are well stemmed and full up till the end of the month, and available supplies are exceedingly scarce, though the resumption of work in Yorkshire is causing buyers to adopt a waiting policy in the anticipation that shortly more coal will be released for export abroad. Prices, however, are still high, and for the best Admiralty large descriptions up to 85*s.* is strongly demanded, with Monmouthshire and dry large round 80*s.* Smalls are also very tight, and the comparatively small quantities being disposed of realise from 50*s.* for the inferior qualities up to 70*s.* for the best descriptions, with Monmouthshire grades from 55*s.* to 60*s.* The recent drought has had a serious effect on the production of patent fuel, a number of works having had to suspend operations owing to the scarcity of water supplies. Nominally patent fuel is worth from 80*s.* to 85*s.*, with supplies practically unobtainable. Coke is also scarce and firm, as much as 8*l.* per ton having been conceded, while makers are now asking 8*l.* 5*s.*

Newport.—The miners have returned to work in larger numbers this week, but outputs are still insufficient to meet the demand, and prices are firm up to 80*s.* for Monmouthshire large coals and from 55*s.* to 60*s.* for small steams.

The Drought and Shipping.—As a result of the recent drought and the cutting off of the local water supply by night, it has been decided that no hydraulic machinery shall be worked at the Bute (Cardiff) and Penarth Docks by night until further notice. Arrangements have been made for loading operations to proceed during the day in two shifts of 6 hours each, with half-an-hour break in each shift for meals. Thus actual working time is reduced from 16 hours to 11 hours per day, and this is likely to have serious consequences, for already the docks is congested with shipping. Thus a good proportion of the world's tonnage is not being used, and until the workers realise that the restriction in outputs is causing this waste of shipping, which should be employed in carrying away cargoes to pay for imports, food prices which are to a large extent responsible for the feeling of unrest are bound to remain high.

JAPANESE SHIPBUILDING DEVELOPMENTS.—In view of the extensive shipping programme lately decided by the Nippon Yusen Kaisha, says *The London and China Telegraph*, the company has increased the capital of the Yokohama Dock Company to 10,000,000 yen with a view to providing building capacity for the vessels which they intend to construct. At the same time the shipping company have practically decided to establish a marine and fire insurance company largely in their own interests, with a capital of 10,000,000 yen. The Osaka Shosen Kaisha manages a similar institution—the Osaka Marine Insurance Company. The shipbuilding programme of the Nippon Yusen Kaisha includes three freighters of 10,000 tons each, three passenger boats of 20,000 gross tons each (the first in all probability to be built in England), two or three passenger boats of 6,000 tons, two vessels of the Suwa Maru type for European trade. The cost of this programme aggregates 90,000,000 yen, which is to be taken from the Reserve Fund. It is also proposed to utilise the balance of the Reserve Fund (100,000,000 yen) for building a further 500,000 tons of shipping at an average cost of 200 yen per ton. The whole programme is to be completed within three years.

AN HISTORIC POWER STATION.

(*For Description see Page* 242.)

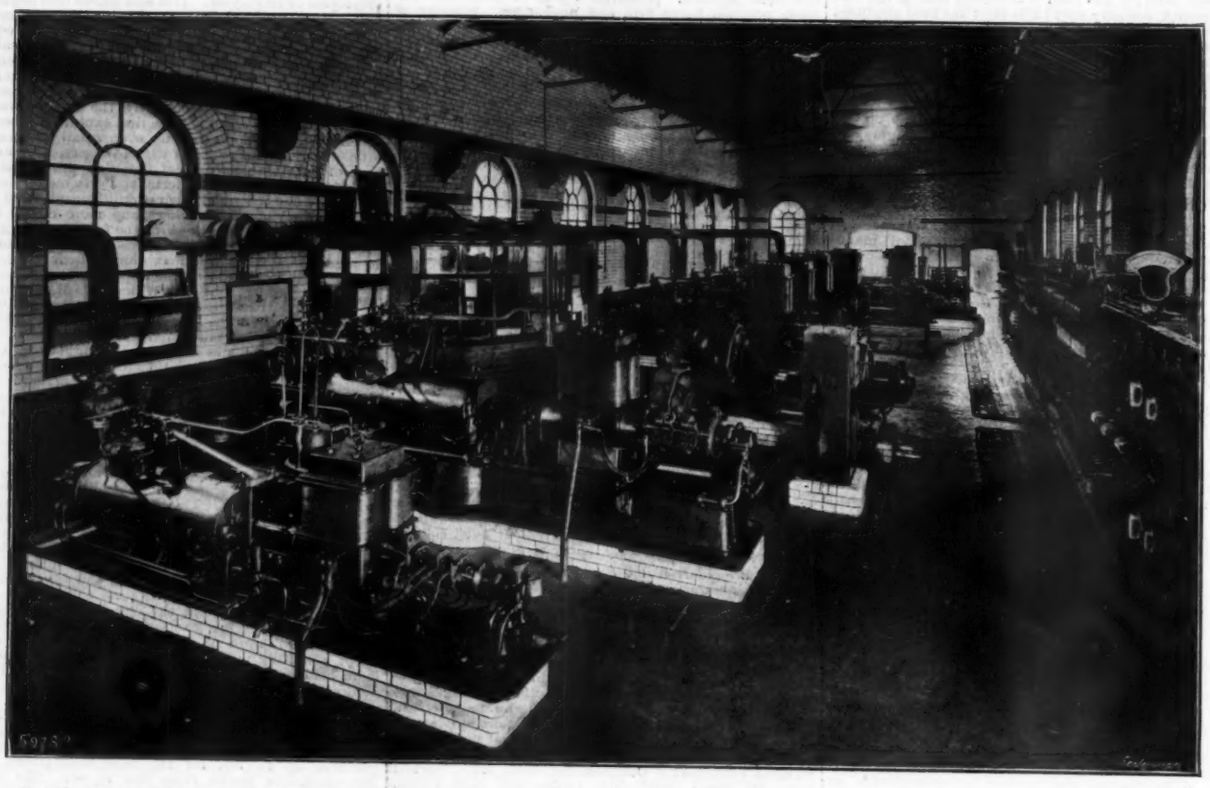


Fig. 3. Turbo-Generators A to H, as Marked on Plan; Messrs. C. A. Parsons & Co., Limited, Heaton, Newcastle-on-Tyne.

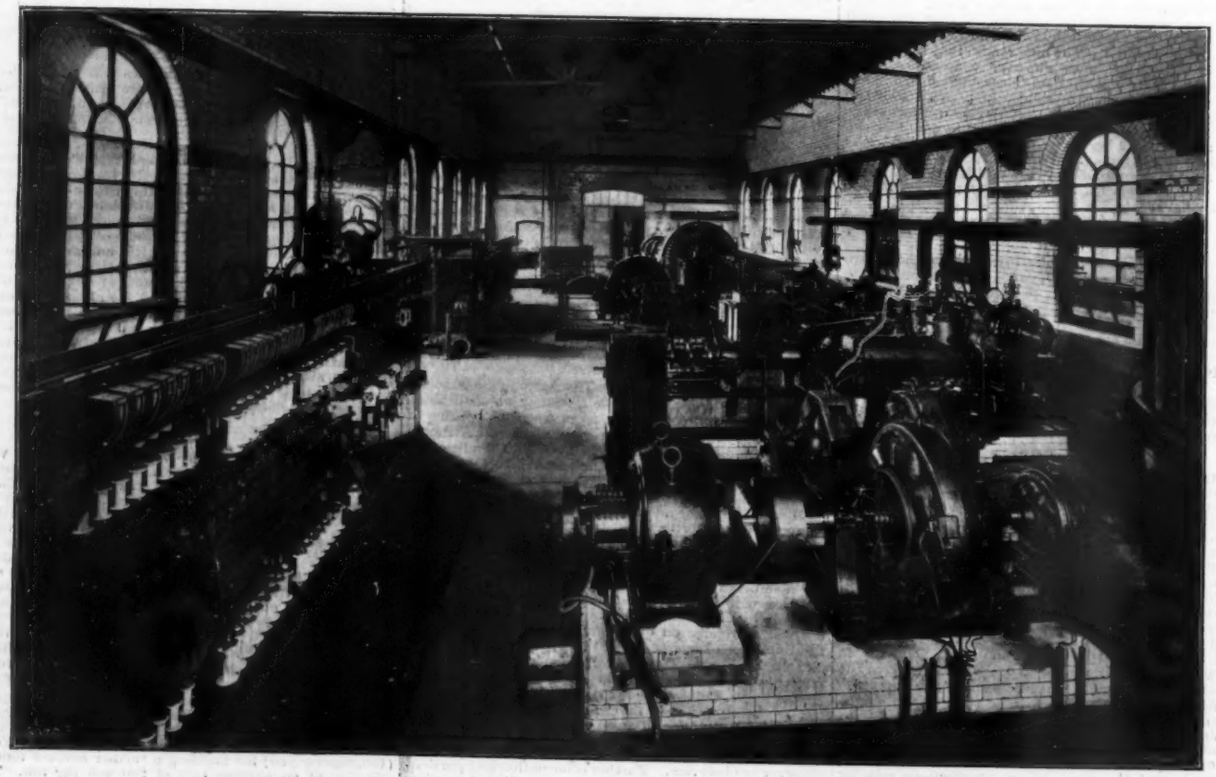


Fig. 4. Turbo-Generators G H J K L, as Marked on Plan; Messrs. C. A. Parsons & Co., Limited, Heaton, Newcastle-on-Tyne.

HELL GATE BRIDGE, NEW YORK.

MR. GUSTAV LINDENTHALL, CHIEF ENGINEER.

(For Description, see Page 236.)

Fig. 16.

LOCATION OF CAISSONS AT ELEVATION +5·0.

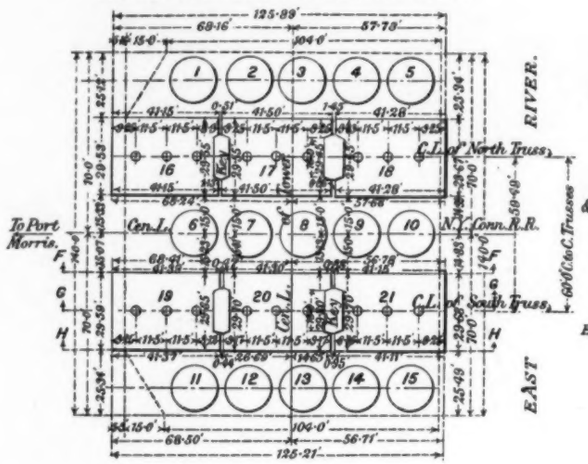


Fig. 18.

SECTION G.G.

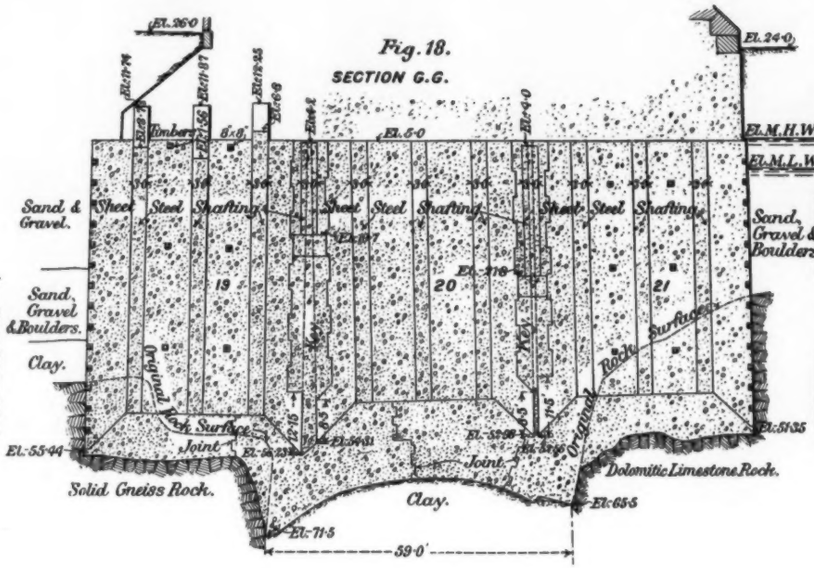


Fig. 20.

PLAN SHOWING LOCATION OF ROCK AT ELEVATION OF CUTTING EDGES.

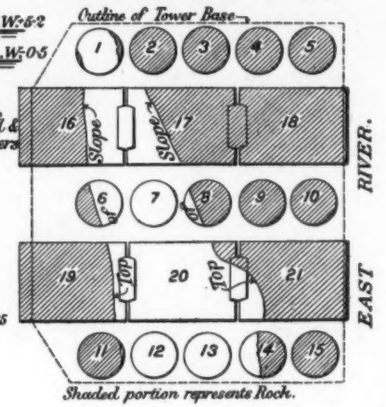


Fig. 17. SECTION F.F.

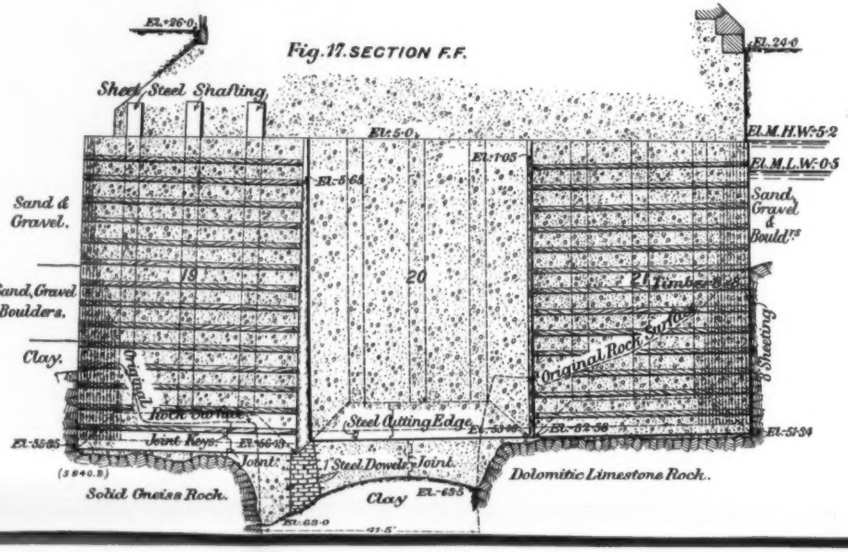
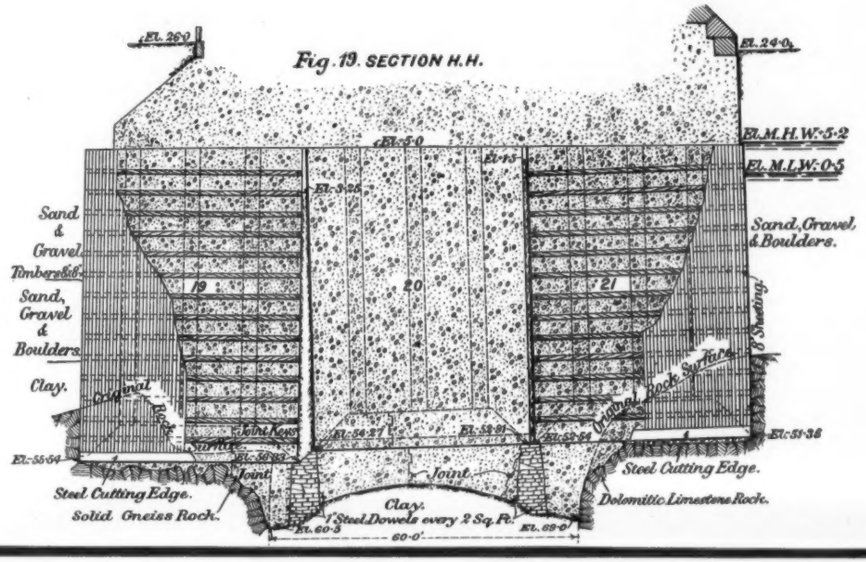
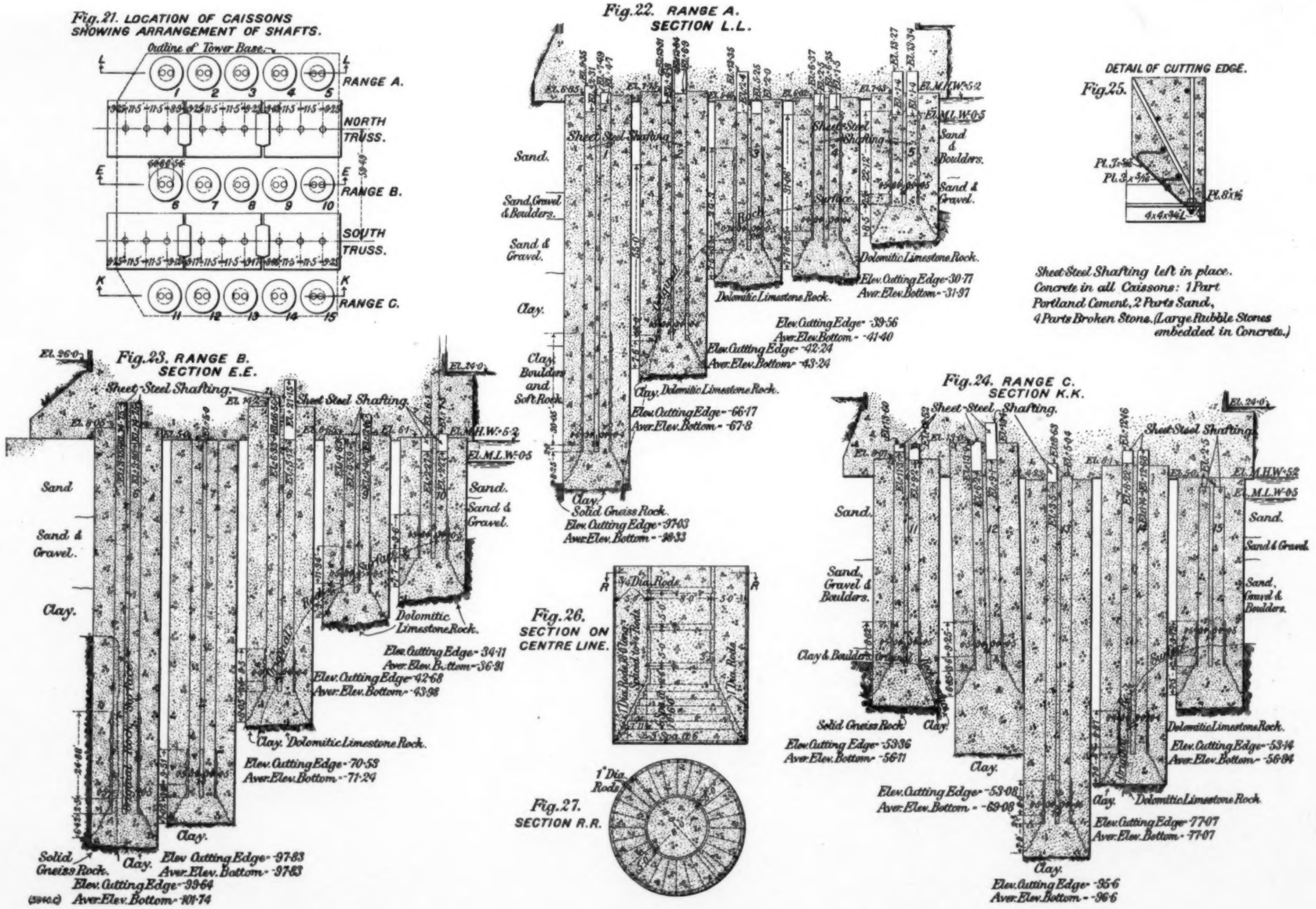


Fig. 19. SECTION H.H.





FIGS. 16 TO 27. DETAILS OF FOUNDATION OF WARD'S ISLAND TOWER.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication, and certainly not later than Monday morning.

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With a Two-Page Plate of the HELL GATE BRIDGE, NEW YORK.

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In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, AUGUST 22, 1919.

THE GOVERNMENT AND INDUSTRY.

EVERY day brings clearer and fuller evidence of the need for increased production if the country is to recover financial strength. But the difficulty here, as in every conception of national duty, is that the individual fails to realise that his or her own contribution is necessary. This applies even to members of the Government departments, as well as to each unit in the organisation of industrial undertakings. The long-expected statement by the Prime Minister on the legislative programme to assist industry, made in the House of Commons on Monday last, opened with an enunciation of this view, and with forcible examples of the critical state reached from the industrial standpoint. Mr. Lloyd George stated that the "critical fact of the situation is that we are not paying our way, and we shall never do so until we have immensely increased production. We are spending more, we are earning less; we are consuming more, we are producing less." The proposals of the Government must primarily be examined at the present moment to determine whether they will assist towards a reversion to the pre-war financial and manufacturing conditions. The proposals have been long delayed, and the degree of uncertainty as to what they would be, associated with their inevitableness, has tended to check enterprise. A waiting policy has excusably been adopted by manufacturers, so that the great national production machine has not yet been converted to peace uses, far less to overcoming the momentum of the stopping down consequent on the attainment of peace. If, however, the proposals are at once clearly enunciated, so that manufacturers, merchants and shippers know exactly what is before them, then the delay may be excused, in view particularly of the strenuous task of arranging peace. But it must be said at the outset that the Prime Minister has not succeeded in laying down, with any degree of definiteness or detail, what the Government intend to do in connection with the control of exports and imports.

The one definite pronouncement was in connection with the mining industry, and all who realise the value of a satisfactory fuel supply will welcome the decision of the Government against the nationalisation of that industry. The royalties are to be purchased by the State, and in connection with them a fund is to be instituted to improve the general condition of the miners and their families in the way of housing and other amenities. The coal mines will be grouped in areas, and the owners will be required to carry out a scheme of amalgamation of neighbouring mines within a limited period, say, two years. To prevent inflation of capital or over-capitalisation, such amalgamations are to be subject to the approval of the Government, and must conform to any conditions laid down by the Government for the protection of the general body of coal consumers. The miners will have representation on the board of directors, but their share in the management is to be confined to co-operation in shaping the general conditions of the industry, without interfering with the executive control of the individual mines. In its broad outlines the scheme follows that proposed by Sir Arthur Duckham, and commended by us at the time of its publication (see ENGINEERING, vol. cvii, page 843). The details, of course, will require to be very carefully considered, as success or failure obviously depends upon them. The Government have prepared a scheme, and it is a pity that fuller details of it have not been given, as the Prime Minister's object was to enable the public fully to consider it during the Parliamentary recess.

This applies with equal force to the proposals of the Government in connection with trade. The Prime Minister pleaded vigorously for a consideration of the new problems with which we are faced, in consequence of the war, without regard to past predilections or opinions. The Government policy, so far as imports and exports are concerned is embraced in three proposals. The first is dumping, regarding which we recently wrote (see page 183 *ante*). The definition is, the "exporting to this country of goods from a foreign land at less than the cost at which they sell in the country of origin." This, however, does not cover imports from Asiatic countries, where a low standard of living tends to low wage cost and selling prices, which if operative here would distinctly result in lessening our standards. The Government, we are told, have decided to submit to Parliament proposals which will effectively deal with dumping, but as to what these proposals are no information was vouched. The belief is that there will be prohibition of such imports rather than tariffs. The second proposal has reference to the difficulties in trade due to "vagaries and fluctuations of exchange values." "The American market is against us, while the German market is simply extravagantly in our favour," the English sovereign to-day fetching 82 marks as compared with 20 prior to the war. In this case the Board of Trade is to be equipped with emergency powers to check a sudden and undue importation of goods at prices altogether below the cost of production in this country, owing to the collapse of exchanges. It is believed that here also the intention is to work under import licences. The third proposal has reference to the "shielding of unstable key industries." There has always been difficulty in defining the exact meaning of "key industry." Mr. Lloyd George put four tests: (1) Whether the industry was revealed to be essential for war or for the maintenance of the country during the war; (2) whether during the war it was discovered that the industry had been so neglected that there was an inadequate supply of goods produced in the industry for the purpose of equipping ourselves for the essential task of war; (3) whether it was found necessary for the Government to take special steps to promote and foster the industry during the war; (4) whether, if that special Government support were withdrawn, the industry could maintain itself at the level of production which war has shown to be essential to the national life. We had again quoted the classic cases of synthetic dyes and optical glasses or lenses. But until the Government produce their Bill, with a definite schedule of so-called key industries, it would be well to refrain from consideration of the question. The method of meeting this case is, again, to be by the Board of Trade having power to prohibit the import of goods except under licence, and to prevent excessive imports a fee is to be charged for the licence. The industries, too, may continue to be subsidised, but care will be taken that no undue profits shall be made at the expense of the community.

A difficulty which arises in connection with all these proposals is that the present system of permitting certain imports by licence expires on September 1. The large programme of the Government cannot be passed by Parliament until late in the year, and the President of the Board of Trade had to intervene late in the debate in the House of Commons, to explain that while the general licensing system was to terminate a fortnight hence, goods which were products of key industries in this country would be retained on a new list of key industries to be published, and that these would continue to be the subject of licence on imports. Ultimately this scheme will be merged into the new proposals of the Government.

The Prime Minister's statement dealt also with the problem of labour unrest, and he spoke hopefully about the work of the National Industrial Council which has recently been organised. One cannot but regret that more has not been done in the way of instituting Whitley Councils in the works and in districts. The National Council, however, in conferences between the employers and workers, have drawn up a scheme to regulate the number of

hours of employment per week, and already a Bill has been introduced in Parliament to carry this scheme into operation. The proposed Act is for a 48-hours' week, but this may be made higher or lower by recommendation of the Joint Industrial Council, the Conciliation Board, Trade Board, or by agreement between organisations of employers and workers in any class of employment. Regulations are also proposed in connection with the working of overtime, and no doubt on this point the Bill will be subject to searching consideration in Grand Committee. Another Bill, agreed to by the National Council, has been introduced, in order that a commission may be constituted to inquire into, and report on, minimum time rates of wages and for purposes connected therewith. In this inquiry regard is to be had to the cost of living in the various districts. The commission is to make recommendations as to the methods and successive steps by which the minimum time rates of wages should be brought into operation and the machinery by which they may be varied as and when occasion arises. Exemptions, however, are contemplated in the case of infirm and incapable workers and in other exceptional cases, and the commission are required to indicate the method by which such exemptions should be given effect to. An interesting point in the Bill is that normally the sittings of the commission will be public, although the commissioners may in their discretion sit in private to hear any part of the evidence.

There were several other proposals adumbrated in the Prime Minister's speech, but these may be dismissed in a few sentences. Reference was made to increased industrial research and experiment. The Government propose to submit a Bill in the autumn for the control and development of water power throughout the country. The Prime Minister said that there was a "vast reserve of power that ought to be harnessed for industrial purposes in this country, especially in view of the coal difficulties," and he instanced the case of Italy's ability to protect itself from the fact that it had no mineral deposits. On this question we have written quite recently (vol. cvii, page 475). One further scheme which promises to become effective is the allocation of 26,000,000*l.*, as a banking trade account, to give credit to such countries as Serbia, Roumania and Poland, in order to enable them to resume trade relations with this country. There is some hope, too, in the proposal to improve the communications between the various parts of the Empire. Already ships are being laid down for this purpose. Mr. Lloyd George also expects much from the Transport and Electricity Bills, and no doubt one of the early results will be increased rates for goods traffic, in order to meet the higher cost of labour, &c. In order to remove that disparity between the pre-war rates of railway freight and those possible in coasting steamers the Government propose to refund the difference between the rates in the case of such goods as are ordered to be sent from port to port by water transport.

It will thus be seen that the programme of the Government is an extensive one, and we prefer to await fuller details before attempting any analysis, far less any condemnation. Our final remark is that what the Government should do they should do quickly.

HIGH-PRESSURE GAS STORAGE FOR MOTOR VEHICLES.

In our article published last week (*vide* page 214 *ante*) on the recent report of the Inter-Departmental Committee on Gas Traction, we referred briefly to the remarks of the committee on the storage of gas at high pressures for use on motor vehicles, and remarked that the views of the committee appeared to be open to criticism. The matter is one of great public importance at the present time, and we therefore return to the subject and propose to deal with it more fully.

The view of the committee with regard to the use of steel cylinders as gas storage vessels on motor vehicles may be gathered from the following preface to its detailed consideration of the subject: "The commercial extension of gas traction by the use of compressed gas depends upon the adoption of equipments which comprise steel cylinders as containers. The sum total of experiences with flexible containers during the past three years makes it clear to us that whilst this class of equipment has proved to provide a cheap and serviceable alternative to petrol under war conditions in some thousands of cases, relatively few commercial users of road motors and practically no private motorist will continue under peace conditions, with metal cylinders and compressing plant available, to accept the obvious inconveniences inseparable from the use of such flexible containers (gas bags) unless petrol supplies fail or the price of that fuel keeps above, say, 3*s.* a gallon."

They then proceed to discuss the composition and construction of cylinders, and in an appendix provide a suitable specification for three types composed of different grades of steel, any or all of which they regard as suitable for the storage of gas at high pressure in motor vehicles.

Whilst they unfortunately fail to differentiate sufficiently between such cylinders and those employed in the ordinary compressed and liquefied gas trades, the first type mentioned in the specification corresponds to the seamless cylinder now manufactured for those trades. We imagine, however, that it is included more as a matter of courtesy to the Cylinder Committee of 1895 than with any serious intention of supporting it as a type desirable for present-day construction. The present committee, in fact, appears to have freely absorbed the fetish of light-weight cylinders. Reviewing the recommendations of the committee of 1895 they say: "We are of the opinion that many commercial and economic transport developments which can be realised only by the fullest degree of permissible encouragement for the production and application of indigenous fuels will be seriously retarded if advantage be not forthwith taken of new and scientific methods that are recorded as having been adopted during the intervening twenty-four years in the steel-making and cylinder-making industries." These new and scientific methods they attribute to ". . . the all-round improvement of works control and inspection due primarily to the necessity for the steelmakers to comply with the specifications of motor-car and aircraft manufacturers, and thereafter to the necessity on the part of cylinder-makers to meet the most exacting demands of the Royal Air Force as regards light yet strong and ductile cylinders for use in aeroplanes and airships."

We have no wish to controvert all this, but it occurs to us as being a poor argument in support of coal-gas as a substitute for petrol, in heavy commercial vehicles that its adoption will be seriously retarded unless it is stored in cylinders analogous to those employed on military aeroplanes and airships.

Our own view is that whatever form of container is employed for compressed gas in place of petrol, whether on a pleasure car, a motor 'bus, or a commercial vehicle, the relative weight involved and space occupied by corresponding units of power will be found under all normal conditions a very serious obstacle to the employment of compressed gas. It is somewhat remarkable that nowhere in the report does any calculation on these points appear to be given. We venture, therefore, to rectify this omission and have selected for the purpose a cylinder made in accordance with the second specification furnished by the committee, which is for a high-carbon steel, and permits a working stress in the metal of 11 tons per square inch.

It was stated by the committee in their interim report, and confirmed in the present one, that "250 cub. ft. of ordinary town gas are on an average equivalent to 1 gallon of petrol. This finding has been confirmed both with flexible and rigid containers." The only mention of container weight we can find in the report is in connection with the semi-rigid type. Discussing one of these the committee says: "Such a container complete with valve weighs only 120 lb. for a capacity of 250 cub. ft. of free gas and a working pressure of 45 atmospheres, the external dimensions before charging being 10 ft. in length by 10 in. in diameter. This class of container is approximately one-third (sic) the weight of any cylinder made in high-carbon or alloy steel for any given volume of gas."

The committee nowhere suggests a suitable capacity for high-pressure containers, but one capable of holding 250 cub. ft. of free gas at a pressure of 120 atmospheres is implied in the foregoing extract and would be a convenient standard, as its contents are equivalent to 1 gallon of petrol. A cylinder of this capacity, 8½ in. in external diameter, of the requisite length, and made in accordance with the committee's second specification would weigh with gas approximately 195 lb. (not 360 lb., as the foregoing extract from the committee's report would imply). The weight of 1 gallon of petrol is approximately 8·2 lb., say, 10 lb., allowing an equivalent proportion of weight for its container. Therefore (disregarding cylinder valves, reducing valves and other accessories), to store coal-gas in cylinders under the most favourable conditions on a motor vehicle, involves 19 times more weight than its equivalent in petrol.

The space occupied by 250 cub. ft. of gas compressed to 120 atmospheres (disregarding the cylinder and accessories) is 2·08 cub. ft. The space occupied by a gallon of petrol is 0·16 cub. ft. Therefore, to store coal-gas in cylinders involves 13 times more space than its equivalent in petrol. In other words, with the same storage capacity a motor vehicle will travel 13 times as far on its petrol supplies as it will on gas. These are cogent and incontrovertible facts which at once limit the use of coal-gas to vehicles radiating within 10 miles or 12 miles of a charging station, or which can travel regularly between charging stations about 25 miles apart. It is, therefore, quite certain that unless the compressed gas system pays for motor-bus traffic, which can be most readily adapted to this method, it will pay for none other. We gather from the report that at present, as stated above, the system is being experimented with only by the London General Omnibus Company, but with encouraging results. We shall await further details with much interest.

The committee recommends that cylinders should be recharged in position in the vehicle, and they are apparently satisfied, as a result of experiments conducted at the National Physical Laboratory, that vibration or impact due to slackness in the supporting bands for cylinders so placed, does not demand any special precaution as the noise occasioned under such conditions should lead to the defect being remedied before any appreciable injury can result. There is, however, no suggestion as to the periodical removal of cylinders for inspection, and no reference appears to be made in any portion of the report to periodical re-testing or re-annealing. Much space is devoted to useful directions regarding compressors, storage of gas at filling stations, pressure-reducing valves and other accessory parts, together with model regulations which are stated to be based on those employed by the British Oxygen Company, yet no allusion is made to that company's system of testing or annealing cylinders which was approved and adopted by the Cylinder Committee of 1895. This omission is accentuated by the fact that the present committee "recommends adherence to the recommendations of the 1895 committee as regards markings on cylinders and also the said committee's recommendations concerning: (*a*) Cylinder fittings; (*b*) safety-valve on charging side of compressor; (*c*) records; (*d*) left-handed threads to external connections on cylinders to hold combustible gases and such cylinders to be painted red." They then proceed to recommend "the use forthwith for traction purpose of working pressures up to 2,250 lb. per square inch, subject to compliance with their cylinder specification," which "for traction purposes" should "forthwith replace that of the Home Office Committee of 1895."

We have already pointed out that this new specification deals with three types of cylinders. The first and second we have already referred to. The third involves the use of steel containing 3·5 per cent. to 3·75 per cent. of nickel and 0·25 per cent. of chromium. We do not propose to seriously discuss the first or the third type. The first because it is virtually the existing trade cylinder of proved reliability, but no doubt capable of reasonable modification, as we pointed out in a recent article on Gas Cylinders. The third because our personal experience does not indicate that nickel steel yet

forms a reliable or suitable material for commercial gas cylinders, either from the point of view of construction or price. Furthermore, we could not with our present knowledge subscribe to a working stress of 14 tons per square inch in the metal of any cylinder employed commercially, either for the fixed storage or transport of high-pressure gases, and we regret to observe that such a stress is sanctioned by the Committee for cylinders of this type. Such cylinders manufactured under close inspection and supervision may be justified for military requirements, but we remain quite unconvinced that at present they are a sound commercial proposition.

We imagine that the second type of cylinder is the one most favoured by the committee itself. The conditions specified both for its material and manufacture appear to correspond in all essentials with the latest American practice as sanctioned by the Interstate Commerce Commission. These cylinders have not yet been long enough in service, even in the United States, to ascertain precisely the cumulative effect of fatigue and wear and tear in the metal, and it certainly appears to us that cylinders of such thin wall section must require periodical normalising under suitable heat treatment and subsequent hydraulic testing to ensure prolonged reliability in use.

Apart from the somewhat remarkable absence of any pronouncement from the committee on these points, the general terms of the specification are sufficiently exacting to ensure a reliable cylinder where lightness is a more important consideration than price or durability. We confess, however, that we regard this specification with some misgiving for the report is not without indications of a desire to recommend its adoption in the compressed gas industry. Careful fire treatment and the introduction of high carbon and alloys will undoubtedly produce a tough steel of high tenacity, but not invariably uniform in quality, and to tell the truth we are unable to find in the committee's specification any striking indication of the recent developments referred to. Nearly twenty years ago we had an opportunity of inspecting and testing a nickel alloy steel cylinder manufactured by an eminent firm of cylinder makers in France under conditions almost identical with those now put forward by the committee, but we are not aware that any serious demand for this type of light-weight cylinder has hitherto arisen even in cases where price is a secondary consideration.

We venture to think that what is required in the compressed gas industry is a cylinder which forms a reasonable compromise between types 1 and 2 of this specification, the conditions relating to type 2 to be brought one-third of the way towards those of type 1. This would mean a carbon content in the steel between 0·35 per cent. and 0·43 per cent., a maximum working stress in the metal of 10 tons per square inch and other conditions to correspond, including an appreciable relaxation in some of the general terms of the specification which, as they now stand, are obviously too severe for No. 1 type cylinder. If such a specification as we propose is based on the standard filling pressure of 120 atmospheres and includes suitable directions for periodical re-annealing and re-testing, we think it represents an adequate concession to the scientific methods which have been introduced since 1895. It is only fair to recognise that the compressed gas industry has itself contributed in no small measure to these methods, and we believe that with their knowledge of the treatment to which gas cylinders are to-day exposed, the representatives of that industry are by no means so eager for the introduction of thin cylinders as appears to be officially assumed.

THE CENTENARY OF JAMES WATT, 1819-1919.

THE commemoration of the centenary of Volta in 1899, of the Fulton Centenary in 1907, when Admiral Seymour took a British Squadron to the Hudson, and of the tercentenary of John Napier at Edinburgh in 1914, will long be remembered by all who were privileged to be present. Such international gatherings, playing as they do an important part in the fraternisation of men of science, have been impossible during the last five years. The altered conditions, however, now lend themselves to the observance of such commemorations, and the approaching recognition of the centenary of Watt, who died at Heathfield Hall, Birmingham, August 19, 1819, bids fair to rival in interest and value either of the gatherings referred to above. Though born in Greenock and for nearly twenty years connected with Glasgow, Watt's greatest work was, as will be gathered from memoir published in our present issue, done during his twenty-five years' partnership with Boulton, and Watt was a resident of Birmingham for forty-five years. Under these circumstances it has been arranged that the principal events in connection with the commemoration will take place at Birmingham on September 16, 17 and 18. Arrangements have been made for a memorial service in Handsworth Church, where Watt, Boulton and Murdock are buried, a gathering at Heathfield, Hall, where Watt's private workshop is preserved as he left it, and a visit to the famous Soho factory. Further items in the programme include a centenary dinner, visits to some of the earliest Watt engines, and a Degree Congregation of the University of Birmingham, when honorary degrees will be conferred on distinguished engineers and scientists. Particulars of the various meetings can be obtained of the Honorary Secretary, Mr. R. B. Askquith-Ellis, Chamber of Commerce Buildings, Birmingham. The objects of the centenary committee are set forth in a small pamphlet, and include, first, the endowment of a James Watt Professorship of Engineering to promote research in the fundamental principles underlying the production of power and the study of the conservation of the natural sources of energy; secondly, to erect a James Watt Memorial Building, and, thirdly, to publish a memorial volume. The committee desire that the city of Birmingham should become to the engineer what Stratford-on-Avon is to the lover of Shakespeare and what Mecca is to the followers of Mahomet. The centenary will, we understand, be recognised also at Greenock, while the Director (Mr. F. G. Ogilvie) of the Science Museum at South Kensington has arranged an exhibition of Watt models, apparatus and machinery—in which the Museum is singularly rich—supplemented by loans from the Boulton and Watt Collection in Birmingham Reference Library, from MSS. in the possession of the Boulton family and other sources. Catalogues of this interesting exhibition will, it is expected, be available at the end of this month. The activity of the various authorities, and especially of the Birmingham Committee, is much to be commended. The gathering is certain to be a unique one, while the subscription list should contain the name of every engineer throughout the length and breadth of the British Empire.

THE BOURNEMOUTH MEETING OF THE BRITISH ASSOCIATION.

WHEN the British Association adjourned at Newcastle-upon-Tyne in September, 1916, it was with the understanding that, circumstances permitting, the Association was to reassemble at Bournemouth the following autumn. Circumstances did not permit, and the Bournemouth meeting will only be opened a few weeks hence, on September 9. Never before had the sequence of meetings been interrupted since 1831. The intervention of the war did not mean leisure and ease to the officials of the Association, however. The decisions to cancel two meetings were only taken when they forced themselves upon the Council, and the negotiations and general machinery of the Association had to be carried on, though the funds were cut off. An appeal to the members for subscriptions—practically the only source of income of the Association—had to be made together with the announcement that the 1917 meeting had to be abandoned. That appeal did not at once meet with the hoped-for response. But members would have been very sorry to let the British Association become a war victim, and when the 1918 meeting, planned for Cardiff, was definitely cancelled, it was resolved at the same time to hold, in 1919 at any rate, a conference in London, if the regular meeting could not take place.

The Council of the County Borough of Bournemouth had, however, renewed its invitation, when the invitation for 1917 had to be withdrawn, and thus the Association, having last met in one of the oldest cities of the kingdom, in Newcastle-upon-Tyne, will resume its proceedings in one of its most modern towns. It will be the first time that the Association goes to Bournemouth, the first time probably that it visits so essentially modern a health resort, neither a university town nor industrially prominent, noted chiefly for its scenic charm and mild climate. Cheltenham may chronologically first be mentioned among the quiet health resorts which have entertained the Association. That was in 1856; but Cheltenham is an educational centre with a very interesting mediæval history, though still a small town. Brighton, which the Association visited in 1872 and later again, is very modern to all appearance, but it was a Flemish settlement and possesses some old buildings and a church from Henry VII's reign. Southampton (1882 meeting) will presently be referred to. Southport, where the Association met in 1883 and again in 1908, offers perhaps the closest parallel to Bournemouth; the first Southport house was an inn, built on the foreshore for the bathers in 1791, and by 1800 the population of Southport was only 800 to rise to 10,000 inhabitants by 1861. A hundred years ago Bournemouth had just begun to exist, though Hampshire was, in the Saxon age of the House of Cerdic, as much the ruling county of England as the London district is now. Alfred the Great had his navy yards, nearly a thousand years ago, at Portsmouth and Southampton. Christchurch, five miles east of Bournemouth, is the ancient Twyneham—the name indicates its position between the Hampshire Avon and the Stour Rivers—and owes much of its fame to the Priory Church which was rebuilt by Ralph Flambard, the hated justiciar of William II Rufus, who was imprisoned by Henry I, but died peacefully as Bishop of Durham in 1128. When Christchurch had over 3,000 inhabitants in 1804, reeds, pines and heather stretched all along the coast from Christchurch to Poole; the census of 1871 gave to Christchurch 42,000 inhabitants, while Bournemouth had 5,906. At present Bournemouth, with 80,000 inhabitants, has left Christchurch far behind.

A Devonshire man, L. D. G. Tregonwell, locally honoured as the founder of Bournemouth, is credited with having built the first house (later annexed by a hotel) on the site in 1810; Portman Lodge, opposite the Winter Gardens, passes as the oldest house in existence. Before that and for some time afterwards the "free-traders," in other words smugglers, were the main frequenters of the valley of the Bourne River as they were of every sheltered inlet on the Channel and the coast generally in the decades of high protection. There was a little fishing and farming; an o'd map of 1642 marks Allom (alum) House in Boscombe, now an eastern suburb of Bournemouth, where copperas was made. But that industry has long since become extinct, and if the war had not brought cordite works to the district, one might say that Bournemouth has hardly any industry. Nor has it any history in the ordinary sense of the word, and is not less happy for that want, and the Bournemouth literature seems almost restricted to local guide books. The 11 miles of tramway from Christchurch to Bournemouth and Poole and the local railways and boats take the visitor to Beaulieu and its Cistercian Abbey of King John's reign, to Blandford and Branksea, to Corfe Castle, where King Edward the Martyr was murdered in 978, to Poole, Swanage and Wareham, to Dorchester, a Roman settlement, and to Lymington and the Buckland Rings, another Roman camp—all full of historical interest. About Bournemouth itself, historians and archæologists have little to say. We read in the official guide, which is to be presented to members that "within the space of a mile from the outskirts (of Sandbourne) every irregularity of the soil was prehistoric, every channel an undisturbed British track way; not a sod had been turned since the days of the Cæsars." The passage is quoted from Thomas Hardy's "Tess of the D'Ubervilles," in which Bournemouth is said to figure under the name of Sandbourne. We do not know the peculiar circumstance which preserved the surroundings of Bournemouth so

strangely prehistoric. But the railway only reached Bournemouth in 1870 from Christchurch, and with the railway connection came the rapid development of the town, which jealously guards the beauty of its woods, shore and cliffs, and of the Bourne, a rivulet, only 6 miles in length.

Though Bournemouth is a city of open grounds, the old member of the British Association will probably find it far easier to attend to his work than it has been at other meetings. Having once discovered, without difficulty, the Reception Room in the fine Municipal College he need not worry to look out for notices directing him to the various section rooms. For the spacious college will harbour on its several floors and in the Engineering Annexe all the 12 section and committee rooms in addition to the offices of the honorary local secretaries and refreshment rooms; only the evening discourses will be delivered in the Winter Gardens. Few towns, if any, have been in a position to centralise the meetings so entirely—at any rate, within recent decades—and the point is of more importance than one might think. Joint discussions of several sections will again be a feature of the meeting. Quite apart from these, members would often like to take their instruction in a measure peripatetically and to migrate from one section to another in order to listen to papers they are particularly interested in. The presidential addresses are purposely not all to be read at 10 a.m. on the Tuesday morning so as to enable members to hear more than one address. If the sections meet in the same building, that can conveniently be done; if members have to move from one part of the town to another, they may prefer not to risk finding the discussion in which they were going to take part already disposed of. The point counts especially for meetings of moderate attendance, and Bournemouth is hardly expected to be crowded, though there is every promise of a good, instructive meeting.

Peace celebrations have been held. But grave war problems, direct and indirect, remain with us, and the war may influence the proceedings at Bournemouth more even than it did at the previous three meetings in Australia, Manchester and Newcastle, which fell in the actual war period. In the first instance it will again be a short war meeting; it will last only from Tuesday, September 9, to Saturday, September 13, instead of the old full week, from Wednesday to Wednesday; but the sectional proceedings will open on the Tuesday morning, and not on Wednesday, as before. The president-elect, the Hon. Sir Charles A. Parsons, F.R.S., will, on the Tuesday evening, strike the keynote with his presidential address on Engineering and the War; at least, that is anticipated, for the presidential addresses are not disclosed before their delivery. From the provisional programme of the sectional Transactions issued by the Council, it is certain that submarines, aviation, and air-photography, radiotelegraphy, tanks, transport, finance and taxation, food production, industrial fatigue, the relations between employer and employed, colonisation and frontiers will be among the chief subjects to be discussed.

In his address to the Engineering Section G, Professor J. E. Petavel, F.R.S., will deal, we understand, with the part played by engineering during the war with special reference to organisation, standardisation, production, invention and research, and with the effects of these factors on the economic and industrial future of the country. Sir Tennyson d'Eyncourt will speak on Tanks, Commander A. L. Gwynne on Submarine Mining; Aviation in its various aspects will be dealt with by Dr. L. Bairstow and Colonel Cave-Brown-Cave; Com. C. D. Burney will describe the Paravane; the problems of Thermoionic Valves and Wireless in Aircraft will be raised by Professor W. H. Eccles, Professor C. L. Fortescue, Major Erskine Murray and Captain J. Robinson; Professor Bryan will read a paper on Noise from Air Screws; Professor C. E. Inglis has a paper on Portable Military Bridges, Colonel H. T. Tizard one on the relation of Engine Power to Height, and Professor R. J. Walker one on Geared Turbines. Professor W. M. Thornton will speak on Heat Insulation and on Gaseous Ignition by Hot Wires, Professor F. W. Burstall on a New Optical Indicator, and Professor J. C. McLennan on the Water Power of Canada. The report of the Committee on Complex Stress is to be discussed on the Tuesday after Professor Petavel's address. For the afternoons excursions are planned to the Tramways where the oxy-acetylene welding and the sorbitic treatment of rails *in situ* is to be demonstrated; to the Royal Engineers Training Camp near Christchurch; to the Poole Gas and Water Works; and to the Holton Heath Cordite Factory, this latter in conjunction with the Chemical Section.

Mars will not rule in Section A, Mathematical and Physical Science. But Professor A. Gray, F.R.S., of Glasgow, will in his presidential address dwell upon lessons the war has taught us as to the necessity of education in mathematics and physics; Professor G. W. Walker will contribute a paper on Seismology after the War to Professor H. H. Turner's report on Seismology, while the discussions of Thermoionic Valves and their Oscillations and of Radiotelegraphy and the Diffraction of Electric Waves, by Professors Eccles, Fortescue, and G. W. Watson, Mr. B. S. Gosling, Major Vincent Smith and Major Whiddington, dealing more with physical features than the cognate papers brought before Section G, will introduce war questions again. War reminiscences may crop up during the communication by Professor A. S. Eddington and Mr. E. T. Cottingham on the Total Solar Eclipse of May 29. The other astronomical papers by the Rev. A. L. Cortie and Lieutenant-Colonel Stratton, on Nova Geminorum and Nova Aquilae, will be spectroscopical; the discussion on Relativity, which Professor Eddington and Dr. Silberstein will open, and Professor Houstoun's papers on the Ether of the Perihelion of Mercury and on the Interpretation of the Quantum, as well as the mathematical papers by Professors A. R. Forsyth and H. Hilton, will probably avoid the war, with which the two papers on Luminosity and on the Ionisation of Argon and Helium by Electron Collisions, by Mr. Horton, in conjunction with Miss A. C. Davies and Miss D. Bailey, will not be concerned either. Nor will Dr. T. E. Stanton's communication on Viscosity at High Pressures and Sir George Greenhill's report on Wave Motion touch upon war problems.

In his presidential address to Section B, Chemistry, Professor P. Phillips Bedson, of Armstrong College, Newcastle, will discuss two very actual problems, the periodic law of Mendeleieff and the position of chemists in relation to industries. Succeeding him, Professor Sir William Pope, General H. Hartley, Lieutenant-Colonel C. D. Crozier, and Professor Boswell will at once dive into war questions, with papers on Chemistry during the War, Chemical Warfare, High Explosives, and Geochemistry during the War. Communications from the Holton Health Cordite Factory, by Dr. Thayness on Bacteriology and its Application outside Medicine, and by Mr. J. Reilly on Distillation of Organic Compounds and on Intermolecular Rearrangements, &c., will in a way be preparatory to the visit to the Factory. Of the remaining papers the report of the Fuel Committee, and Dr. R. Lessing on the Chemistry of Coal Tar will interest the engineer. The other papers by Drs. Lowry and Perman on Equilibria; by Professor E. C. C. Baly on The Molecular Phase Hypothesis, a Theory of Chemical Activity; by Professor A. Lapworth on The Positive and Negative Rule in Organic Researches, and by Professor R. Robinson on Conjugation of Partial Valencies are of theoretical interest.

Section C, Geology, President, Dr. J. W. Evans, will, so far as we are aware, keep aloof from the war and will concentrate on the very interesting geology of the district to which a number of excursions are being arranged; but we know little about the programme. In Section D, Zoology, President, Dr. F. A. Dixey, many questions will come up in connection with Professor Denny's paper on Grain Pests, and Professor G. F. Nuttall's on Lice in their relation to Disease. But the Geography Section, E, under Professor L. W. Lyde, will have ample opportunity for references to the war. There are papers on Geography (by General Sir Henry Wilson), and on the Geography of Imperial Defence (by Dr. Vaughan Cornish); on Air Photography and Long-distance Air Routes (by Lieut.-Colonels McLeod, R.E., and Towler); on The Survey and Archæology of Mesopotamia (by Colonel Beazeley and Mr. Campbell Thomson), on The Dodecanese (by Mr. G. H. T. Rishbeth), on The Frontiers in Eastern Europe and on the Colonisation of Africa (by Miss M. Newbigin and Sir Alfred Sharpe), on Crete (Mr. Trevor Battye), and fortunately also on The Static Power of Melting Ice (also by Mr. Battye), on The Site of Westminster (Miss H. Rodwell Jones), and on some other subjects.

Section F, Economic Science and Statistics, over which Sir Hugh Bell, Bart., will preside, should be one of the most interesting. The Rt. Hon. F. Huth Jackson, P.C., will present considerations on A National Alliance of Employers and Employed; Unemployment in Eastern Canada is to be brought up by Mr. Gilbert Jackson; Sir Charles Wade will raise the question of Price-Fixing, with special reference to Australian experience; Sir George Gibb and Mr. W. M. Acworth will speak on Transport, and Colonel Sir G. G. Beherrel on The Advantages of Accurate Statistics as shown in the Transportation Service in France. Finance and Taxation and the Gold Standard are to be discussed by Mr. J. C. Stamp, Mr. Hartley Withers and Mr. R. G. Hawtrey, and there is a report on The Replacement of Men by Women in Industry (by Professor Kirkcaldy and Miss Grier). Further, in joint meetings with the Physiology, Section I, the Influence of the Six-Hour Day on Industrial Efficiency and Fatigue is to be discussed, and in conjunction with the Education Section H, the problem of Business in Relation to Education is to be attacked by Sir Herbert Morgan and Mr. L. R. Fay. The Educational Section under Sir Napier Shaw, F.R.S., Director of the Meteorological Office, has other important discussions on its programme. The Fundamental Principles in Education, Continuation Schools, Science and Botany Teaching (together with the Botanists), and the Position of Private Schools; even the Teaching of English is to be discussed, which may strike some people as superfluous; and Bishop Welldon and Canon W. Temple offer their opinions on Training in Citizenship. So many well-known names are mentioned with regard to the educational discussions that we rather refrain from giving any.

A few words on the other sections. Section H, Anthropology, will, under Professor A. Keith, discuss the Age of Local Antiquities, and will listen to a good many interesting papers on the archæology and ethnography of the United Kingdom and of the Channel Islands, over to which Dr. R. R. Marett will take an excursion, as well as on archæological researches at the Salonika front, in Greece, Malta, in Finland and in the Russian borders. The papers on Cults of the Heathen Goddesses of India, by Mr. W. Crooke, and on Saint Jago, the Evolution of a Patron Saint (Spain), by Mr. H. J. Perke, may form peculiar contrasts. In Section I, President Dr. Nöel Paton and Professor W. D. Halliburton will discourse on butter and margarine, a timely subject, while the Botany Section, over which Sir Daniel Morris will preside, will in conjunction with Section M, Agriculture, discuss Forestry Problems. In this last Section M, Professor W. Somerville, of Oxford, will occupy the chair and Food Production during and after the War, Crop Production, Dairying and Cattle Foods will be the main subjects for discussion. Agricultural Wages and British Agricultural Policy after the Napoleonic Wars (by Mr. R. V. Lennard) and the Electrical Treatment of Seeds (by Dr. C. Mercier) will also be considered.

We have said enough in this brief summary to justify the expectation of a most interesting topical meeting. There is a certain danger of overlapping when so many speakers are to deal with the war aspects of varied problems. It is, on the other hand, surprising frequently how different speakers approach the same problem from different standpoints, and some of the names we have mentioned offer a sufficient guarantee for the originality and diversity of their communications. Yet it may, as usually, require both tact and firmness on the part of the chairmen to keep the speakers to the point. There will be, in addition, to the sectional transactions, evening discourses, by Sir Arthur Evans (acting President) on the Palace of Minos and the Prehistoric Civilisation of Crete, and by Mr. Sidney G. Browne on the Gyroscopic Compass; further citizen lectures

(in co-operation with the Workers' Educational Association) by Professor H. H. Turner on Modern Astronomy, by Professor S. H. Reynolds on Purbeck Isle and its Geology, and by Professor J. L. Myres on Women's Place in Nature from an anthropological point of view. A civic reception is planned for Wednesday evening. All the excursions we have mentioned are in charge of the secretaries of the respective sections; there are no general excursions, but Lord Montagu of Beaulieu, chairman of the Conference of Delegates, will show members over the beautiful grounds and ruins of Beaulieu Abbey, and Sir Merton Cotes will permit inspection of the art treasures of East Cliff Hall.

The offices of the British Association in Burlington House, W. 1, will close on September 1; the Reception Room in Bournemouth will be opened on September 8. Mr. C. R. Haley is the local treasurer of the Bournemouth meeting; the local secretaries are Messrs. Herbert Ashling, the Town Clerk; Frank W. Ibbett, M.A., Director of Education; and A. B. B. Scott, J.P., the Corresponding Secretary.

FACTORS LIMITING THE MAXIMUM PRESSURES DEVELOPED IN GASEOUS EXPLOSIONS.

By Major W. T. DAVID, M.A., Assoc.M.Inst.C.E.

1. *Introduction.*—It is well known that the maximum pressures developed during the explosion of an inflammable mixture is only about half that which would be expected from theoretical calculation made on the basis that the whole of the inflammable gas is completely burnt and that the volumetric heat* of the products of combustion is independent of temperature. It is, however, definitely known now that the volumetric heat of carbon dioxide and steam (of which the products of combustion are mainly composed) increases very considerably with temperature. The extent of this increase at the high temperatures developed in explosions is not known with any degree of accuracy, but it is probable that it accounts for some 50 per cent. of the "missing pressure" or "suppressed heat" as it is sometimes called. The remainder of the "missing pressure" is probably due to a variety of causes.

In this paper the suggestions which have been put forward at various times to account for the so called "suppression of heat" are collected and discussed, and some experimental work is suggested which it is thought will throw considerable light on the problem.

2. *Energy distribution at moment of maximum pressure.*—It seems probable that the total heat of combustion of the inflammable gas is distributed at the moment of maximum pressure amongst the following categories:—

(i) Translational or pressure energy of the molecules.

(ii) Internal energy of the molecules which may be subdivided into—

(*a*) Rotational energy of the molecules, and

(*b*) Vibratory energy of the molecules (which gives rise to the emission of radiation).

(iii) Heat loss to the walls of the containing vessel by—

(*a*) Conduction, and

(*b*) Radiation.

(iv) Unburnt gas (that the gas may not all be burnt at the moment of maximum pressure was first suggested by Sir Dugald Clerk).

(v) Dissociation of the CO_2 and H_2O molecules due to high temperature.

(vi) Ionisation and luminescence. (It is thought that at explosion temperatures the energy in this group is small and may be neglected.)

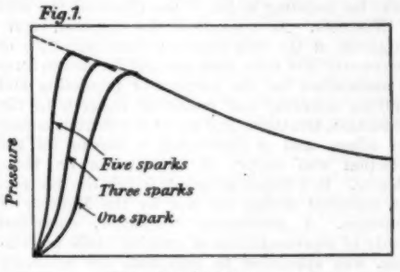
3. *Internal energy of the gaseous mixture.*—The internal energy of a gas includes both the translational and the internal (rotational and vibratory) energies of its constituent molecules. In a gas which is in chemical and thermal equilibrium the translational, rotational and vibratory energies of the molecules will bear some definite relation to each other at any given temperature—though as the volumetric heat varies with the temperature this relation will also vary with the temperature.* If for any reason any one of these energies (say the vibratory energy) is in excess of its equilibrium value a transfer of energy will take place between it and the other kinds of energy (translational and rotational) at a rate dependent upon the temperature, density and the nature of the gaseous molecules.

In a gas which is heated by external means (let us say, for example, by rapid adiabatic compression) the heat energy is at first given to the translational degrees of freedom of the molecules, but sooner or later part of this additional translational energy will be transferred to the rotational and vibratory degrees of freedom of the molecules and the transfer will go on until the equilibrium values are reached.

In a gas heated by internal combustion, on the other hand, theoretical considerations would lead one to suppose that the chemical energy of combination is at first transformed into internal energy of the combining molecules, but the excess of molecular internal energy will be more or less rapidly shared with the translational degrees of freedom of the molecules.†

The rate at which this partitioning of energy proceeds is not known, though it seems pretty certain that at the high temperatures of explosion it is fairly rapid when judged by ordinary standards

Fig. 1.



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of time. It is possible, however, that when judged by molecular time standards it may be a slow process.‡

The author's experiments on gaseous explosions seem to offer a considerable volume of evidence that the vibratory energy of the molecules at the moment of maximum pressure is somewhat in excess of the equilibrium amount corresponding to the temperature.§ Professor W. M. Thornton, too, has come to the conclusion from theoretical considerations that the rotational energy of the molecules at the moment of maximum pressure is above its equilibrium value. Indications, therefore, are not wanting that part of the energy of combustion (possibly a small part) is at the time of maximum pressure hidden away as an excess of molecular internal energy over and above its equilibrium amount; part of this excess would, given time, be transformed into pressure or translational energy.*

Some suggestions for experimental work bearing on this question are made in §6 below.

4. *Heat loss to walls of containing vessel up to the moment of maximum pressure.*—The late Professor Bertram Hopkinson made a determination of the total heat lost to the walls of the containing vessel when a 12·7 per cent. mixture of Cambridge coal gas and air was exploded in his recording calorimeter.† He found that this mixture had lost to the walls of the containing vessel up to the moment of maximum pressure as much as 12 per cent. of the total heat of combustion of the gas present in the vessel. The author's experiments with the same gas in a vessel of much the same size as Hopkinson's show that for a mixture of this strength the loss by raidation up to this moment would be about 4 per cent., while in a 9·8 per cent. mixture the loss was as much as 7 per cent. of the total heat of combustion. It is probable, therefore, that in weak mixtures the total loss of heat up to maximum pressure would exceed even the large figure of 12 per cent. found by Hopkinson for the stronger mixture. The loss of heat up to the moment of maximum pressure is thus of considerable practical importance, and to it must be attributed part of the "missing pressure."

This is confirmed by some experiments made by Hopkinson‡ and the author§ on coal-gas and air mixtures contained in a vessel with reflecting walls. With a 15 per cent. mixture of coal-gas and air the maximum pressure developed was about 3 per cent. higher when the loss by radiation was checked (reflecting walls polished) than was the case when the radiation was absorbed (walls blackened). Hopkinson also made some experiments with a cast-iron vessel whose interior surface was coated with a layer of paper (a poorly conducting substance), and although he found a much slower rate of cooling after maximum pressure when the walls were so coated than when they were not so coated he could detect no difference in the maximum pressure developed in the two vessels. These experiments were made, however, with a pencil indicator, and it is considered that further experiments should be made with the more accurate optical indicator before definitely drawing the conclusion that explosions in vessels with walls made of a material of low thermal conductivity do not give a greater maximum pressure than those in vessels whose walls are made of a material of high thermal conductivity.

The author is of opinion that some useful information as to the maximum pressures which would be obtained were the heat loss entirely checked might be derived from a series of experiments made with an inflammable mixture fixed by a varying number of sparks. The kind of result which it is thought would be obtained is shown in Fig. 1. By increasing the number of sparks (in series) the time of explosion would be shortened and consequently the heat loss would become less. A curve (shown dotted in Fig. 1) drawn through the points of maximum pressure would, if produced so as to cross the ordinate drawn through zero time, give the maximum pressure which would be produced if it was developed instantaneously, and therefore with no heat loss.

In such a series of experiments it would be desirable to work with a vessel of, say, 1 cub. ft. or 2 cub. ft. capacity, whose walls are composed of a material of low thermal conductivity and lightly

* The volumetric heat of a gas is the measure of the amount of heat required to raise the temperature of unit volume of it 1 deg. C. when the volume is constant. See First Report of British Association Committee on Gaseous Explosions.

* The volumetric heat increases with the temperature and the ratio of the molecular internal energy to translational energy therefore increases with the temperature. It seems probable from the author's experiments on the emission of radiation in gaseous explosions that this ratio depends to some extent upon other factors as well as temperature, such as density and volume, for the vibratory energy depends upon these factors (see *Philosophical Magazine*, February, 1913, pages 368 and 369). The statement in the text, however, holds for a gas maintained at constant volume and density.

† This theory is supported by some of the author's experiments. In these experiments the intensity of emission is a maximum some time during the explosion period before the mean temperature of the gaseous mixture (which is proportional to the molecular translational energy) attains its maximum value. And, further, when the radiation emitted by a gaseous mixture is reflected back upon itself during explosion and subsequent cooling, the vibratory energy of its molecules is increased over and above its value when the radiation is absorbed by the walls of the containing vessel; and this excess is clearly partly transformed into translational energy, for cooling proceeds much more slowly in the reflecting vessel than in the blackened vessel. (Phil. Trans. A., vol. ccxi, pages 380 and 394.)

‡ Whatever the truth as to this may be it is highly probable that at low temperatures the rate of partitioning is not so rapid as at high temperatures (see Phil. Trans. A., vol. ccxi, page 49, footnote), and it would appear to be a matter for investigation whether this factor has any influence on the specific heat values of CO_2 obtained by Clerk's method of adiabatic compression and expansion in a gas-engine cylinder. If it has it would tend to make the values of the specific heat obtained from the compression part of the curve too low and those obtained from the expansion curve too high. Measurements of the emission of radiation (which is a function of the vibratory energy of the molecules) made during compression and expansion of the CO_2 would test this point.

§ An examination of this evidence will be made in another paper.

* It should be noted that this excess of molecular internal energy would not be included in true volumetric heat measurements, could they be satisfactorily made at the high temperatures of explosions. Such measurements should, of course, be made under conditions in which the molecular energies are in equilibrium with one another.

† Proc. Roy. Soc., A., vol. lxxix, page 147.

‡ Proc. Roy. Soc., A., vol. lxxxiv, page 155.

§ Phil. Trans., A., vol. ccxi, page 394.

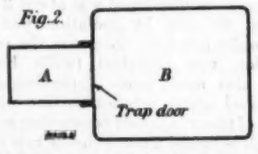
silver-plated on its interior surface, so as to check as far as possible heat loss by conduction and radiation.

5. *Incomplete Combustion and Dissociation.*—Sir Dugald Clerk's experiments in which he allowed a gaseous mixture after attaining maximum pressure to pass over cold wire gauze (thus quenching further chemical combination) seem to show definitely that all the inflammable gas is not burnt at the moment of maximum pressure, or at any rate that there is uncombined gas (due to dissociation, for example) present in the explosion vessel at this moment, even in strong mixtures. We might call the calorific value of the inflammable gas minus the chemical energy of the fraction of uncombined gas at maximum pressure the effective calorific value—that is effective so far as transformation into thermal energy is concerned. Theoretical considerations would lead one to believe that the fraction of uncombined gas at this moment would be dependent upon mixture, strength and density, and, perhaps, also upon the nature of the material composing the walls of the containing vessel; and the effective calorific value would thus vary with these factors.

It is very important from the point of view of gas-engine calculations that the effective calorific values should be determined for various strengths and densities. It is considered that these could be satisfactorily determined by means of experiments similar to those designed for determining calorific values by the bomb method, but in which the gaseous mixture after attaining maximum pressure is allowed to mix quickly with a large volume of cold quenching gas, such as carbon dioxide. The values so obtained might be checked by chemical analysis of the mixed gases when the experiment is completed.

What would appear to be suitable apparatus for these experiments is diagrammatically sketched in Fig. 2. In vessel A (closed by a trap door) is contained the inflammable mixture, and in vessel B

Fig. 2.



(which should be from 5 to 10 times the size of vessel A) is contained the cold quenching gas, CO_2. A plate of thin glass designed to break up at maximum pressure might perhaps be found efficient as a trap door.

6. *Measurements of Internal Energy of Gaseous Mixtures.*—It is thought that fairly reliable estimates of the internal energy of gaseous mixtures of various strengths and densities could be made from data obtained from the experiments suggested above. From the experiments suggested in §5 would be obtained the net amount of chemical energy which has been converted into thermal energy; and from those suggested in §4 would be obtained the maximum mean temperature corresponding to this amount of thermal energy.

The values of the internal energy of the gaseous mixture so obtained would differ from those corresponding to the mean volumetric heats, because—

(i) There is probably an excess of molecular internal energy over and above the equilibrium value; and

(ii) There are large variations in temperature in the gaseous mixture at the time of maximum pressure, and consequently the volumetric heats vary in different portions of the gaseous mixture.

As regards (i), as has already been pointed out, the excess depends largely on the rate of partitioning of energy between the various degrees of freedom of the molecules. It would be interesting to take pressure records in the experiments suggested in §5, provided the apparatus were designed in such a way that the mixing took place rapidly after reaching maximum pressure, and that the interior surface of the vessels were coated with a layer of material of low thermal conductivity so as to check loss of heat as far as possible. If the volume of B is sufficiently large the temperature of the mixed gases would be reduced to a value at which volumetric heats are fairly accurately known. If the internal energy which the mixed gases possess and which is known (see first paragraph of this section) differs considerably from that calculated from the volumetric heat at the temperature of the mixed gases, it would indicate that the partitioning is slow and that the excess molecular internal energy is considerable.

7. *Conclusion.*—In this paper an attempt has been made to summarise present knowledge of the properties of an exploded gaseous mixture at the moment of maximum pressure, and some speculations have been put forward which it is believed have experimental foundation. The problem of the gaseous explosion is, however, exceedingly complex, and these speculations are offered with much diffidence.

The labours of the British Association Committee on Gaseous Explosions have thrown the problem into perspective, while at the same time emphasising the fact that the present state of knowledge is most unsatisfactory. It is hoped that they will continue their investigations. The importance of the subject will be readily appreciated when the difficulties experienced in the design of large gas engines are remembered.

NOTES.

Non-Ferrous Metals Research.

We have already published particulars (see pages 316 and 317 of our last volume) of the scheme by which the Government proposes to encourage various British industries to undertake research work, for assisting which it has allocated the sum of 1,000,000*l*. As a result of this proposal, representatives of the non-ferrous metals industries of the country met some time ago and decided to form an association for the purpose of promoting and applying scientific and industrial research to the production, treatment and use of non-ferrous metals and alloys, and of instituting a bureau for the collection and supply of information on these subjects. It is hoped to include in this the information collected during the war by the Ministry of Munitions. A provisional committee, composed mostly of representatives of existing trade associations, was appointed to undertake the necessary preliminary work, and the memorandum and articles of association, which are completed, have now been approved by the Government Department of Scientific and Industrial Research. These articles provide for the establishment of a research institute and experimental workshop, as well as for the setting up of an information bureau, and, as soon as the necessary licence has been issued by the Board of Trade, it is proposed to establish the association on a permanent basis. Subject to certain conditions, one of which is that research is conducted on a sufficiently large scale, the Government will contribute an equal part of the cost of the work up to a maximum contribution of 5,000*l*. annually, but the remainder of the cost must be defrayed by the industry. All manufacturers, and large users, of non-ferrous metals and alloys, are therefore invited to support the movement and to join the association, which is known as the British Non-Ferrous Metals Research Association, and has offices at 29, Paradise-street, Birmingham. A number of important firms have already made subscriptions, and several prominent metallurgists have agreed to assist the association in an advisory capacity. The secretary of the provisional committee is Mr. Ernest A. Smith, A.R.S.M., M.Inst.M.M.

The Colour of Inorganic Compounds.

The study especially of organic compounds, derivatives of which can be prepared in endless varieties, points to a connection between structure and colour. Though the nature of that connection is by no means understood, there is a good deal of evidence in favour of the view that the electrons involved in selective absorption—which, when in the visible spectrum, gives rise to colour—are the same electrons which take part in the chemical union of elements, that is, the valency-electrons. Some elements like the alkali metals are only credited with one, non-variable, valency; to other elements variable valencies are assigned, three or five, *e.g.*, to nitrogen, and one of these valencies is considered the "normal valency;" but there is considerable disagreement as to this normal valency and to the possible variable valencies. We know little about the forces determining the stability of the electronic arrangements, *i.e.*, the forces which resist small displacements of the electrons from their equilibrium position. Those forces will, however, be a measure of the resistivity of a compound, which is connected with the possibility of an element's existing in different valency-states, but which has no direct connection with the thermodynamic stability of a compound or of a valency-state; that thermodynamic stability is measured by the total work necessary to separate the parts of a molecule. According now to the magneton theory of the structure of the atom, proposed by Parson and chemically developed by G. N. Lewis, there is for all atoms—except those of hydrogen and helium, which stand apart—one particular arrangement of the electrons which has maximum stability. In this arrangement the number of electrons, grouped around the positive nucleus or in it, is either 8 or 0. All other arrangements of electrons, consisting of 2, 4, 6, 10, and to a still greater extent, arrangements of odd numbers of electrons, are less stable. To understand the colour rules which F. Russell von Bichowsky has deduced from these special atoms of Lewis (Journal of the American Chemical Society, of March, 1918, and later issues) we should first give a few of the "normal" valencies: Sodium, copper and silver, as well as fluorine, have the normal valency 1; mercury, 2; thallium, 3; tin, 4; nitrogen, 5; oxygen, sulphur, tungsten, 6; chlorine, bromine, iodine, 7; iron, manganese, nickel, platinum, 8. Thus chlorine would be surrounded by seven dots, if a dot represent an electron, sodium would have one dot, and in sodium chloride the chlorine would be symmetrically surrounded by eight electrons (two dots on each of the four sides). A substance like sodium chloride has maximum stability and zero colour (*i.e.*, it is colourless) according to Bichowsky, the selective absorption being confined to the invisible ultraviolet. Titanium has several valencies and gives the chlorides $TiCl_4$, $TiCl_2$, $TiCl_3$, the first colourless, the second yellow (absorption in the violet), the third blue (absorption in the red). In these chlorides the electron groups round the titanium atom contain 6, 4, 2 electrons respectively, and the general rule is that in salts of the same elements the colour changes from colourless to yellow, green, blue, violet, black as the groups vary from 8 to 6, 4, 2 and to 1, 3, 5, 7, or in that order. The atom-colour of every element itself in its normal state is zero, and compounds of the non-variable valency atoms are likewise colourless; when the valency is variable, the colour turns more blue when the valency changes from the normal; thus the copper fluoride CuF is colourless, the CuF_2 is blue. The colours of compounds are sometimes merely additive; sometimes the colour may be more blue than the sum of the colours would indicate. The colours of the elements themselves are those of their ions, and not many elements are sufficiently known in the ionic state. The rules proposed by Bichowsky are not simple; but the arguments are suggestive, especially also as they concern inorganic as well as organic components.

Elgar Scholarship in Naval Architecture (1919) and Earl of Durham Prize.—The Elgar scholarship in naval architecture has been awarded tby the Council of the Institution of Naval Architects to Mr. W. G. Green, of Chatham Dockyard, and the Earl of Durham prize to Mr. W. G. Perring, also of Chatham Dockyard.

Regulation of the Rhone.—The French Government has under consideration a Bill which approves the programme of the works for regulating the Rhone from the Swiss frontier to the sea, from the points of view of motive power, navigation, irrigation and other agricultural purposes. The expenditure is calculated to reach 2,600,000,000 francs. The mean power of the 20 hydro-electric works forming part of the programme is about 715,000 h.p., capable of supplying 4,000,000,000 kw.-hours, or the equivalent of the power obtainable from 5,000,000 tons of coal. The carrying out of the scheme will take a maximum of fifteen years, and its operation is to be in the hands of a concessionaire company formed in large majority of representatives of the districts bordering the river, including representatives of chambers of commerce and of the City of Paris. The company is to have a share capital of 250,000,000 francs, also the right to issue bonds up to 10 times this share capital. The bonds are to be guaranteed by the State, and the latter is to nominate two-fifths of the members of the board of directors and the chairman.

LITERATURE.

The Year-Book of Wireless Telegraphy and Telephony, 1919. London: The Wireless Press, Limited, Marconi House, Strand.

A BULKY volume is now required to record the past achievements and to indicate the future developments of wireless telegraphy and telephony. This annual, which does so much to assist communication, both at home and abroad, had its birth shortly before the war, and has had to struggle against adverse conditions, but that catastrophe, that did so much to arrest progress, has not been able entirely to prevent the growth of so beneficial a movement, or to stop the regular record of its increasing activities. The Wireless Press, Limited, has struggled manfully to maintain the regular appearance of the official organ, and to extend its usefulness. Prominent among the difficulties to be overcome were, on the one hand, the war regulations and the censorship restrictions which have hindered the publication of much available matter that would have aroused public interest, while, on the other, electrical engineers have been reticent concerning their inventions, awaiting better times, when unfettered publication would be permitted and the protection of foreign patent offices might be invoked.

In a work of this kind, arrangements and indexing are of the first importance, and these particulars have evidently received careful attention. The mass of facts collected is so large, and, in a sense, so incoherent, that without efficient guidance through its pages, one cannot thread his way to the single item sought. Experience from previous issues has been utilised, and the result is satisfactory. We can only note a few of the main features.

A calendar for the current year that appears in June seems a little belated, and though supplemented by similar information for the year that has gone and the year that is to come, such addition is of small service in the case of the calendars of nations and races that do not accept the Gregorian scheme, and will not go far to fill important lacunæ in the variable time arrangements sanctioned by those nations who do. Next, we have a record of the development of wireless telegraphy since Faraday discovered the effects of electro-magnetic induction in 1831. Morse, in 1842, and Bowman Lindsay, in the following year, both of whom foresaw dimly the capacities and the prospects of radio-telegraphy, are names almost forgotten among the early experimenters in wireless telegraphy, of whom we may well be reminded, but some other worthies fail to figure in the list. One particularly notices the omission of Sir Oliver Lodge, especially at a time, when his claims to be recognised as a pioneer have been tardily, but fully, admitted. A later section containing biographical notices of the more prominent electricians, repairs to some extent, the more flagrant omissions noticeable in this historical summary.

These details act, however, merely as an ornamental fringe to emphasize the encyclopædic character of the work and its real sphere of usefulness. The main object is to assist commerce and industry, by placing accurate and carefully-selected information at the command of all. The legal organisation of the system of wireless telegraphy has resulted from the deliberations of various conferences, and the laws and regulations embodied in the different conventions are many and confusing. The sifting and arrangement of all that is material in these conventions, so that the untrained may, without expert advice, learn the amount of assistance he can expect, and the extent of his own obligations, is to render no small service to the commercial world. This work of dissection and arrangement is thoroughly and efficiently done. Here the rules for working the scheme of international communication are fully set out, the fiscal arrangements between the different countries made clear, and the provisions to secure uniformity and efficient working of the scheme satisfactorily explained. These regulations more closely affect the commercial side of the network of communication, but of hardly less importance are the international conventions adopted with the view of promoting safety of life at sea, and of assisting navigation. All the current rules and statutes are given, and the full text of the generally-accepted agreements is printed in full detail.

Another large section is devoted to a catalogue of the Wireless Telegraph Stations of the World, whether on land or on ship. These tables give much useful information, and show in many instances, the hours of service, the coast charges, and the controlling authority. A supplementary table gives a list of the call letters for land and ship stations. In this section the restrictions enforced by the Defence of the Realm Act have been experienced, and with every effort to ensure accuracy, the editor is doubtful if he has attained it. Other compilations give the codes employed in the distribution of time and weather signals, an extensive bibliography, a dictionary of technical terms in polyglot form, code signals, with other useful data and statistics, generally found in books of this character.

Original articles on topics intimately connected with radiotelegraphy are contributed by several well-known scientists, and form bright spots amid much less readable matter. Dr. Fleming, writing on Maxwell's electro-magnetic theory, endeavours to make the importance of that theory better appreciated, and the grounds on which it has been received more generally intelligible. As an authoritative utterance, we imagine, many will accept the conclusions, but fail to follow the reasoning that demonstrates, that what we call light is "merely an electro-magnetic wave, and that the transverse displacements which constitute that wave are electric and magnetic fluxes or strains." While more preparation is needed than can be provided here, all will be pleased with the too brief historic sketch though some well-known names do not appear in the story as it is told.

Dr. Eccles is hardly so satisfactory in his attempt to discredit the merits of charts constructed by the Mercator method, and to substitute maps based on a gnomonic projection as more serviceable for aviators and wireless operators. He has to meet the formidable objection that the gnomonic projection of every small circle is a conic section, whereas, in some other forms of projection, as that of the bounding cylinder, tangent to the equator, not only would the meridians be represented by equidistant parallel straight lines, but on the developed surface the circles of latitude would also be parallel straight lines perpendicular to the meridians, the distance of any one from the projection of the equator being simply proportional to the tangent of latitude. Seeing that the world's traffic is practically limited to less than 60 deg. from the equator, the cylindrical projection would be admirably adapted for map representation, except for the circumstance that the British Isles are situated in a high latitude. Mercator's principle, or method, of representing the earth's surface on a plane, of which a very good specimen is given at the end of this volume, is not a true projection as generally understood, that is to say, the result is not such a representation as would be formed by drawing lines from the eye through every point of an object to meet the surface on which it is to be delineated. This may be an objection, but a more formidable one is the rather long calculation necessary for determining the length of an arc of the meridian, at least on a spheroidal earth. On the other hand, we are spared such grotesque distortion as that presented by the outline of the map of Africa in the example selected for illustration. Dr. Eccles will excuse us pointing out that the latitude of Greenwich is 51½ deg.

The review by Mr. P. R. Coursey on the method and progress of radiotelephony is not only timely but informing. The difficulties that have delayed progress in this particular direction are clearly perceived, and we are made to appreciate the ingenuity of the mechanical devices that has succeeded in removing or diminishing these obstacles. Foremost was the construction of an efficient transmitter capable of producing a steady stream of oscillations of frequency above the acoustic limit. The quenched spark gaps operated with either alternating or direct current have given satisfaction. With a three-phase supply, an effective sparking rate of 18,000 to 30,000 per second is possible, and such an arrangement is said to give good results. With a direct current supply, it is possible to generate an almost continuous wave. Vacuum or ionic values have proved most useful in generating continuous waves for telephone work, but the design of valve necessary for the efficient generation of powerful oscillations is quite different from that required for ordinary receiving and amplifying. Since high-frequency alternators and frequency raisers offer other means for supplying the needful qualification of rapid oscillation of frequency, this essential may be regarded as satisfied. Of only less importance than the transmitter, is the modulater, and the production of a satisfactory transmitting microphonic apparatus still calls for much research and experiment, notwithstanding what has been accomplished by valve transmitters and valve amplifiers. The difficulty of the problem will be understood when it is remembered that the minute energy of the air-waves constituting the spoken words, must be able to control adequately and faithfully a power output of possibly several hundred kilowatts. A similar disproportionality is also encountered in attempts at relaying to and from land lines, since successful telephony demands that a speaker should be able to converse directly with any selected person, without any intermediate repetition. Kilowatts stand at our command at one end, and microwatts at the other, "while both these extremes must be connected to and be either controlled by, or control, the working of an ordinary telephone line." Mr. Coursey very ably details the direction experiment is taking and the degree of success with which it has been rewarded.

Dr. Louis V. King, of McGill University, discusses the electrical and acoustic characteristics of telephone receivers. The receiver is the final link in the mechanism designed to convert electrical into acoustic energy, and being at the end of the chain has, apparently, escaped that minute examination that the intermediate parts have received. Dr. King describes briefly the main features of the instrument, and at some length apparatus suitable for measuring the electrical and audibility characteristics of receivers. He has little difficulty in showing that the ordinary type considered as a means for transforming electrical energy into acoustic output is an extremely inefficient instrument, and he explains the ability of the telephone receiver to detect very small variations of electrical energy, as due rather to the sensitiveness of the ear as an organ of perception, than to any inherent excellence of mechanical or electrical construction. Some years ago, the acoustic efficiency was stated to be *at most* 1/700, but Dr. King's researches would assign an even lower efficiency. The best results are to be obtained by employing a receiver whose diaphragm is tuned to resonance with the frequency of the telephonic current. The loss with continuous change of frequency from resonance is extremely rapid, and over the range of frequencies ordinarily used the efficiency is extremely low, amounting to only a few parts in a 100,000.

This section, and a valuable section it is, closes with an interesting dissertation on Radio-Frequency Phenomena from the pen of Dr. N. W. McLachlan. Mr. Shoenberg adds some notes on valve patents during 1918, and some further technical analysis is supplied, giving a complete list of British and American applications and patents during the same year.

BOOKS RECEIVED.

Shore Processes and Shoreline Developments. By DOUGLAS WILSON JOHNSON. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 23*s.* net.]

The British Corporation for the Survey and Registry of Shipping. Rules for Classification and Construction. Glasgow: Published by the Association.

The British Corporation for the Survey and Registry of Shipping. Register of Vessels, 1890–1919. Glasgow: Published by the Corporation.

How to Lay Out Turret Lathe Tools. Second Edition. Coventry: Alfred Herbert, Limited. [Price 6*s.*]

The Metals of the Rare Earths. By JAMES FREDERICK SPENCER. London: Longman, Green and Co. [Price 12*s.* 6*d.* net.]

Printing for Business. A Manual of Printing Practice in non-Technical Idiom. By JOHN THORP. London: John Hogg. [Price 7*s.* 6*d.* net.]

"EDUCATION FOR MANAGEMENT."

To the Editor of Engineering.

Sir,—Mr. Vowles, in your issue of August 15, has brought to wider notice a phase of social evolution which undoubtedly demands the deepest attention of all thinking people. As he says in his last paragraph, the ideas are not new; but there is no doubt that the subject is not receiving the attention it deserves from industrial sociologists. Admittedly the problem is a most intricate one to solve, but that is no reason why its solution should not be attempted. The whole question is one involving the entire overhauling of the present social structure from top to bottom, and it seems to the writer, that it is precisely for that reason that no one seems to desire to give it any great sincere and detailed attention.

Mr. Vowles confines his remarks to the problem of management. The hints he gives are most valuable; indeed, the most "successful" manager is he who is the most "human" in his outlook, and who possesses a wide and thorough grasp of the principles of psychology and the dynamics of human evolution. But this application of the principles of sociology to the study of management merely touches the fringe of the larger social problem, with which that of industrial management is inseparably bound up. Just in the same way that advancing working-class education is testing the ability of the present-day manager to perform his duties efficiently, so is that same educational advancement challenging the very *bona fides* of the present structure of the social organism. Whatever it may be labelled—"Bolshevism," "industrial unrest," &c., &c.—there is no doubt that the spread of education among the working classes is causing a great change in their attitude towards industry and commerce, and the economic science on which their operations are at present founded.

Mr. Vowles' appeal on behalf of education for industrial management applies with far greater uniqueness to the national management of the country by the Government—not our own government in particular, but those of other countries as well. Yet, in no other sphere of social activity is there such a woeful lack of sincere endeavour to grasp the essentials of the dynamics of progress. Politicians, and permanent officials do not, or will not, "realise that human relationships are about as permanent as the shapes of the clouds in the sky, that human beings are individual and unique, and that human affairs are therefore less amenable to classification and tabulation than the properties of matter and energy." Neither do they "realise that life is not static but kinetic; that the social, political and industrial conditions of to-day are not permanent." Indeed, it almost seems that they take a diabolical delight in refusing "in some measure" to "foresee and help to determine the conditions of to-morrow."

The same is still true, unfortunately, of a good many of our "captains of industry," though happily, in some quarters, there appears to be an evident change on the horizon.

The educated section of the working classes are, however, not satisfied with the small amount of sincerity displayed by the Government and employers of labour generally in the futile (and sometimes peurile) attempts to pacify their demands for better conditions of existence. There seems to be an utter lack of realisation that the social outlook of the working classes has vastly changed, and that there are thousands of highly well-educated individuals (both technically and sociologically) in their ranks. It can hardly be, surely, that, knowing the trend of industrial and economic evolution, their aspirations are purposely ignored or suppressed. This seems unimaginable; it is akin to sitting on (or near) an active volcano. Personally, the writer feels inclined to attribute it almost entirely to a lack of adequate sociological knowledge and insight on the part of those responsible for the right ordering of the governmental and industrial management of the country.

A genius, seemingly, is wanted to set the nation right. Genius, however, is of little service without some foundation on which to erect its edifice. That foundation we, as a human community, do not possess, and we do not possess it because, as stated previously, no one individual, or group of individuals, amongst our politicians, governmental chiefs, and "captains of industry" seem to consider the point of view of the working classes as one worth while bothering about, in their manipulation of the social machine. Far too many of their deliberations are concerned with the "relationships with matter and energy," and not nearly enough with the "relationship with mind and human action." As Mr. Vowles pleads for a wider reading and adoption of the "Theory of Evolution in Management," so the writer would plead for a more sympathetic consideration of the educated workers' point of view in industrial and social questions, by a similar appeal to the theory of the evolution of dynamic sociology.

It is useless to mark time, or reintroduce the idea of the *status quo* in industrial and economic thought. The process of evolution moves on as inexorably in this department of human activity as in any other domain of nature. Adaptation to change, paradoxical as it may sound, is the only way to ensure a permanent existence; and if our political and industrial institutions are not voluntarily modified by those who immediately control them, in the best interests of an ever-widening working-class consciousness, there can be no doubt that some attempt at a most undesirable social upheaval will be attempted.

Our social administrators, statesmen, and "captains of industry" undoubtedly have the necessary leisure to give this matter their urgent and sympathetic attention.

Palliatives are of no use—they cause more irritation and trouble than the social fester they are supposed to ameliorate. Neither are they based upon an intelligent conception of the forces operating beneath the surface of social appearances. What is most urgently wanted is that the present trend of the complex development of the social system shall be studied in the light of the theory of social evolution. There is plenty of pure scientific and philosophical material to work upon: what is lacking is that very fine and unique development of institutional and constitutional details which characterise human activities in other spheres of science and industrial life. The general principles of bridge design are majestic and grand in their mental conceptions, but it is the correct handling of the details in relation to those principles which ensures its success as a structure when built. So, in the same way, with the social order. The comprehensive principles of social evolution are there to be studied, and it is only by a careful and well-balanced consideration of the numerous and varied interactions of human nature on social institutions that a social order in any way satisfactory and lasting will be developed.

In conclusion, the writer feels he cannot do better than quote Mr. Vowles' eleventh paragraph, with the necessary grammatical modifications. 'Through all their readings, social students will find the theory of evolution the cement which will bind their ideas together. It is the touchstone that will enable them to read critically, and distinguish between science and pseudo-science. For most of the fallacies regarding human relationships arise through the attempt to regard such relationships as static rather than kinetic. Instead of being at the mercy of popular fallacies, they will have arrived at sound conclusions as to social theories—and will have fitted themselves to guide both the community and the nation through the storms of impending industrial conflicts to peace."

Yours faithfully,

Thomas Engleton.

Liverpool, August 17, 1919.

"SOME DEVELOPMENTS OF AIRCRAFT DESIGN AND APPLICATION DURING THE WAR."

To the Editor of Engineering.

Sir,—We are requested by the Right Hon. Lord Weir of Eastwood to ask you to be good enough to correct a clerical error that has crept into the table of "Particulars of Representative British Aero Engines," published on page 111 of your issue of July 25.

The figures for the Napier Lion engine in the columns "Normal Propeller Speed" and "Dry Weight in Lbs.," have become transposed, and, as may be gathered from the figure of 1·86 lb. per horse-power dry weight in the next column, they should read:—

Normal propeller speed, 1,318 r.p.m.
Dry weight in lbs., 840.

Yours faithfully,

Ogilvie and Partners.

Gwydir Chambers, 104, High Holborn,
London, W.C. 1. August 19, 1919.

To the Editor of Engineering.

Sir,—Messrs. Ogilvie and Partners contribute a letter to your issue of August 15 on the date of Drzwiecki's original papers on the blade-element theory of screws in fluids.

The incorrect date—1882—appeared by a purely mechanical error in the present writer's reply to a question by Mr. Green, of the Royal Aircraft Factory: "With regard to priority, Soreau places Drzwiecki's original paper on Marine Screws in 1882, which gives him sixteen years' priority over Lanchester's 'Aerodynamics'." (*Aeronaut. Journ.*, 1914, page 59.) The date of the edition referred to was 1908, and subtracting sixteen years we get 1892, which is the correct date of Drzwiecki's paper. The writer has since been informed, but has not verified, that the date of Lanchester's first edition is 1907, which would make fifteen years the correct priority.

The incorrect date was quoted by A. S. Riach, in his book on "Airscrews" (1916), in reviewing which the present writer noted the error and had an editorial footnote inserted giving the correct date—1892. (*Aeronaut. Journ.*, 1916, page 163.) There is no affectation so crude as the undue quoting of foreign authors, but when a foreign author has an indisputable title it is commonsense to recognise it.

I am, &c.,

A. R. Low.

London, August 19, 1919.

METAL CONSTRUCTION OF AIRCRAFT.

To the Editor of Engineering.

Sir,—I am greatly interested in the stressing of aircraft, more particularly the spars, of which I have had some practical experience. I am therefore interested in Dr. Thurston's article on the metal construction of aircraft in your issue of the 8th inst., especially the notes on spars, on which I should like a little enlightenment.

For example, is the statement that the order of deflection of metal spars is *ten* times that given by Perry's formula for a laterally-loaded strut? If so, how is it that the formula for deflection given is that for simple lateral loading?

And why, in arriving at this formula, is Euler's crippling load taken as the end load? Because when using either Perry or the generalised theorem of three moments it is well to keep the moment of inertia so large that the end load does not approach the crippling load.

Also it is said in the article: "Now, in the case of a long strut, *if the direct stress is ignored*," &c.—by direct stress, what is meant, end loading, as is more general, or lateral loading? The article would lead one to the belief that lateral loading is meant, but if so is it justifiable to neglect it, as in general the deflection due to lateral loading is of more importance than that due to end loading, as the end load is a variable factor, it may even be a tensile load. Finally, 5,500 tons per square inch is given as Young's modulus; is this for duralumin or steel?

I should be glad of enlightenment on these points, as I have used both Perry and the generalised equation, between which there is normally little difference, and I should like to know if they would be in error 1,000 per cent. when applied to metal construction.

Yours faithfully,

W. Hughes.

50, Bellevue-road, Southampton, August 17, 1919.

THE NEW PATENTS AND DESIGNS BILL.

To the Editor of Engineering.

Sir,—My communication in reference to above-named, published in last week's Engineering, has brought me many letters in agreement, showing that I have been merely voicing the opinion of most people interested. As regards the so-called "Bill" itself, to my mind it appears to be the funniest document of the kind I have ever perused, as it seems to consist mostly of a series of provisions, amendments, cancellations, &c., in alteration of the "Principal Act," *i.e.*, the discredited 1907 Act, which still forms the main part of the new "Bill."

I would strongly advise your many readers to obtain a copy of the said "Bill" and judge of the matter for themselves.

Fortunately—although the new "Bill" has passed its third reading in the House of Commons—the "Bill" has still to run the gauntlet of the House of Lords, which has declined to deal with it till next session, so there is still hope that it may there be amended "out of existence" as a leading London daily paper last year suggested that its predecessor, the proposed 1917 Bill, should have been. Meanwhile, I understand an influential committee of inventors, engineers and others interested is being appointed to consider the matter further.

Yours, &c.,

James Keith.

"Dunottar," 17, Kidderpore-avenue, Hampstead,
August 19, 1919. N.W. 3.

THE ELECTRICITY SUPPLY BILL.

To the Editor of Engineering.

Sir,—The excellent leading article in your issue of August 15 rightly calls attention to the improvements which are being made to the Electricity (Supply) Bill by Standing Committee "B" but, curiously, enough, after calling attention to the elimination of railway generating stations, you do not point the obvious moral. Surely this is that the control of electricity supply by the Minister of Ways and Communications can no longer be justified in view of this direct divorce.

Whether the control of electricity supply should remain with the Board of Trade or with a new Ministry of Commerce, or, indeed, should have a separate Ministry of its own, is another matter. My own view is that very much can be said for leaving the control with the Board of Trade, partly because of their past experience and because the five Electricity Commissioners will introduce the necessary new leaven into that department.

I enclose my card, and remain,

Yours faithfully,

"Onlooker."

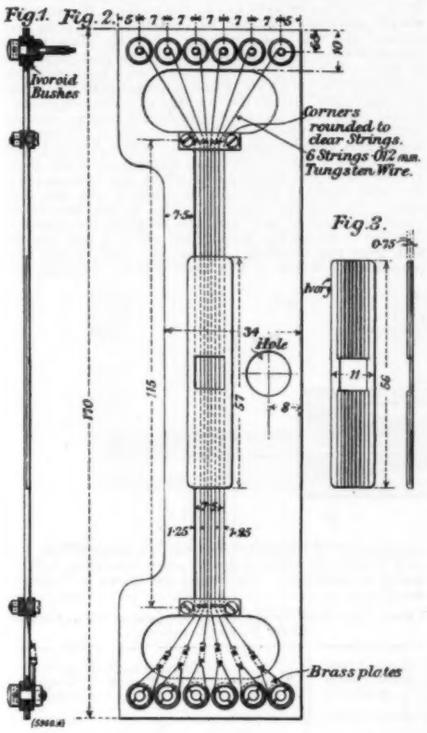
Constitutional Club, London, August 18, 1919.

Manganese in the Transvaal.—The neighbourhood of Krugersdorp, among others in South Africa, has long been known, says *The South Africa Mining and Engineering Journal*, as a manganese-bearing area. The mineral occurs in association with the dolomite beds of the Transvaal system. The journal gives particulars of these deposits and of other manganese occurrences at Caledon, Du Toit's Kloof and Hout's Bay.

Railway Bridge over the Paraná in Argentina.—After receiving the Paraguay and entering the Argentine Republic, the Paraná River has very little gradient on its long southerly course, and flows through largely swampy country. About 200 km. before it enters the estuary it forms the Paraná delta. The Uruguay joins the estuary so that the La Plata River, on which Buenos Ayres is situated, is really an estuary which at Buenos Ayres has already a width of 45 km. There is, so far, no railway bridge over the Paraná at all, and the State of Paraná, in south-eastern Argentina, the Republic of Uruguay (Montevideo) and Southern Brazil are hence not in railway communication with Buenos Ayres. The line from Buenos Ayres to Rosario and further north keeps on the right, western bank of the Paraná, and some railways approach the eastern bank; but the traffic across the river and its various arms is carried on by boats and ferries. The ferry between Ibicuy, on the eastern bank above the delta, and Zarate, on the western bank, further down, takes about 4 hours in crossing. A bridge is now planned to cross the three main arms of the delta, together about 1,500 m. wide, and the land and islands on a length of 20 km. It is to start 5 km. below Ibicuy and to consist of eight spans of 125 m., 110 spans of 80 m., and 333 spans of 30 m. The river has a depth up to 10 m., and firm rock is in many parts ony to be found at a depth of 20 m. Under these circumstances the estimated cost of 170,000,000 francs does not appear high. The project has been worked out by A. Ottonelli, on behalf of the Argentine Government.

THE SIX-STRING EINTHOVEN GALVANOMETER.

CONSTRUCTED BY THE CAMBRIDGE SCIENTIFIC INSTRUMENT COMPANY, LIMITED, CAMBRIDGE.



THE six-string galvanometer of the Cambridge Scientific Instrument Company, which we illustrate in the diagrams Figs. 1, 2 and 3, and the photographs, Figs. 4 and 5, annexed, was especially designed for measuring time signals, sound waves, &c. Our readers may remember that it has done excellent service in determining positions at sea, as stated in Professor W. H. Bragg's lectures "On Listening under Water" which we noticed on page 776 of our issue of June 13 last. In the Einthoven chord or string galvanometer a fine wire replaces the coil of the moving coil galvanometer. The string is stretched in the very narrow air gap between the poles of a powerful electromagnet; when a current passes up or down this string, the string is deflected in a direction at right angles to the magnetic field. The movement is observed with the aid of a microscope which passes through the pole pieces; an enlarged image of the wire may also be thrown by a lantern through the tube on to a photographic screen or a kinematograph film, so as to produce permanent records of the vibrations of the string which are of very small amplitude. In our photograph, Fig. 4, the galvanometer is seen in the centre of the table; the lamp is on the right-hand side, the film on the left of the galvanometer.

Professor W. Einthoven, of Leiden, designed his galvanometer for his physiological researches and especially for the study of the heart and its pulsations, and the instrument has become widely known in this connection. The string galvanometer was soon appreciated also by physicists interested in radio-telegraphy and telephony and in pulsating currents generally rather than in electro-cardiographs, because it is extremely sensitive and dead beat, and almost devoid of self-induction. The ease with which it lends itself to multiple combinations is also noteworthy. The considerations which guided Einthoven in substituting a simple wire for the movable coil of the galvanometer are the following. The sensitivity of any galvanometer is inversely proportional to the square root of the undamped period and to the square root of its resistance; that was established by the early researches of Ayrton and Mather, and the formula for the "factor of merit" of a galvanometer M is given as $M = 100\ D/T^{\frac{1}{2}}R^{\frac{1}{2}}$, where D is the displacement of the galvanometer in millimetres per microampere, measured on a scale at 1 m. distance, T the periodic time and R the resistance of the galvanometer. Einthoven further demonstrated that M varies inversely as the diameter of the wire and the square root of the number of turns. Hence he reduced his coil to one fine wire of

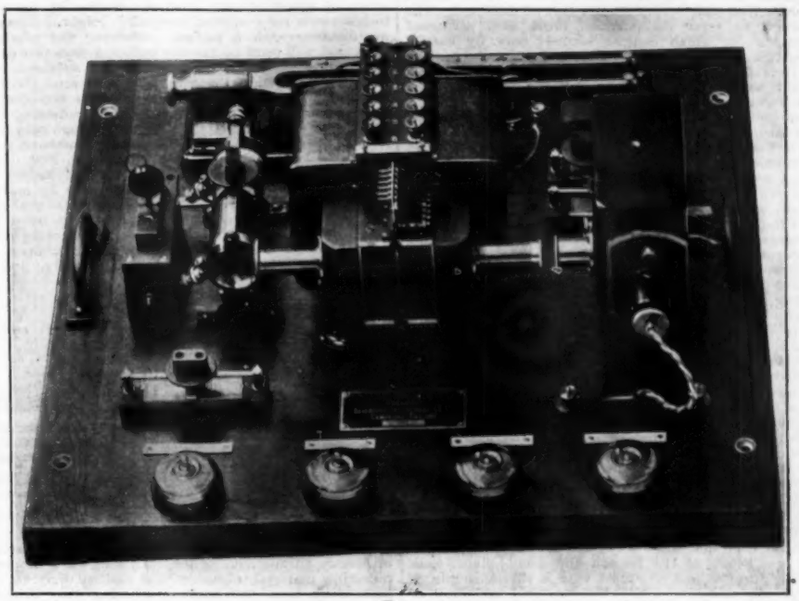


FIG. 4.

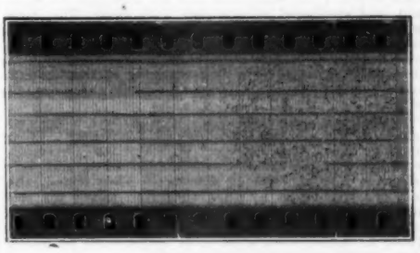


FIG. 5.

silvered glass, gold, silver, platinum, &c.; observing the deflections of the wire directly, he also dispensed with the mirror of the galvanometer, and he made his magnetic field very powerful. The periods of these wires are exceedingly small.

In the instrument illustrated six strings are stretched in the brass frame which fits edgeways into the pole gap, and each of these strings can be inserted in a different circuit. The strings are made of platinum wire or tungsten wire, only 14 μ in diameter, and can readily be mounted in their frame. Our diagrams mark the dimensions in millimetres. At the lower end of each vibrating wire is a small spiral spring of fine phosphor-bronze wire, 0·05 mm. in diameter, which is soldered to a brass plate attached to an insulated terminal on the brass frame. The upper terminal is a square-headed screw to which the upper end of the wire is soldered; by means of a key the screw can be turned, and the tension in the string be varied. In order to keep the wires at the correct distance apart throughout their vibrating portions, an ivory bridge fitted with small stop pins, made of brass, is placed at each end of the vibrating portion of the wires; correct spacing is further secured by a plate of ivory with six grooves which is mounted in the middle of the frame. When the vibrator is in position, the rounded ends of both the upper and lower terminals are pressed upon by two sets of six springs connected to the terminals which can be seen above the field magnet coils in the photograph. To these latter terminals are connected the leads from the circuit under observation. In order to facilitate the insertion and removal of the vibrator, a lever is provided by means of which the pressure can be relieved when required. Dust should be excluded from the upper and lower ends of the vibrating system; this is attained by means of metal covers which are not shown in the photograph.

The usual optical system supplied with this instrument magnifies the movements of the string about 30 diameters on a movable band of photographic paper in a suitable camera. A specimen of the type of record obtained was published by us when we commented on Professor Bragg's lecture on "Listening under Water," on the occasion above mentioned; we reproduce this photograph in Fig. 5. The six blank lines running parallel to the edges of the film are the traces of the six strings. The straight distinct black lines show the string undeflected; in the portions which were vibrating at the moment the lines are indistinct. The transverse lines are produced by a time marking mechanism; a rotating disc inserted in the path of the beam just in front of the film cuts off the light momentarily when a tooth of the disc is passing through the beam. The intervals between the thick transverse lines represent periods of 0·1 second, the intervals between the finer lines 0·01 second. The galvanometer is placed in a central station which is connected by cables to the six coastal stations which receive the records of a disturbance somewhere out at sea and convey them on to the galvanometer. The six stations will be at different distances from the source of disturbances; the six galvanometers will hence be deflected at different moments, and from the intervals the distance and the position of the source can be calculated.

ARTIFICIAL LIMBS AND HELP FOR WAR INVALIDS.—From German technical journals we see that the Permanent Commission for Industrial Welfare, which is an Imperial institution, together with a section of the Prussian War Department, have been issuing a treatise on "Artificial Limbs and Help for Invalids, incapacitated by the War and by Accidents." The book of 1,121 pages, with 1,586 illustrations, is published by Julius Springer, Berlin, and sold at 28 marks (40 marks bound). The editor is Georg Schlesinger, who was mainly active in causing the appointment, in December, 1915, of a committee of the Verein Deutscher Ingenieure for the examination and testing of artificial limbs and for finding suitable occupations for war victims. Before this committee was appointed the Government and various benevolent people had offered prizes for suitable limbs and instruments without much result. The book is divided into three parts. The first part is compiled by medical experts who have made a special study of the problems how relaxed nerves and muscles can be strengthened and developed into sources of power, and the muscles in the stumps of missing limbs can be stimulated into taking up new functions. The excellent work done in this field by the Italian surgeon Vanghetti, twenty years ago—largely overlooked until Professor Stodola, the hydraulic engineer, drew attention to it—has been continued by Spitzy, Sauerbruck, Krukenberg and other contributors to this part. The second part, on the construction of artificial limbs and their use, is by Schlesinger himself, who critically surveys all the instruments with which he has become acquainted. The third part deals with economic problems. The book has been well reviewed, but we have not seen it ourselves.

USE OF OPTICAL PYROMETERS FOR CONTROL OF OPTICAL-GLASS FURNACES.*

By Clarence N. Fenner,† Washington, D.C.

The manufacture of optical glass is a process that demands careful regulation and control at all stages n order that satisfactory results may be obtained. The product, to serve its purpose, must meet stringent requirements, which can be assured only by careful procedure in manufacture. During the greater part of the time that a pot of glass is in the furnace, temperatures should be kept within certain rather narrow limits; a departure on either side is likely to be detrimental to the glass and may result in total loss. If the temperature during melting and fining be low, the melt is likely not to fine properly and the glass will contain quantities of bubbles, or "seed," or it may become milky and unfit for use; too high a temperature, on the other hand, is severe on the pot and may cause it to leak or cast stones, or the increased solution of pot material in the melt may add to the colour of the glass and decrease its transmission. Moreover, variations in the working temperature will mean variations in the amonnt of selective volatilisation and, consequently, variations in optical properties from pot to pot. Furthermore, in the closing stages of furnace treatment, the melt is cooled until a certain degree of stiffness is attained, when the pot is withdrawn. The quality of the glass—its freedom from striæ and bubbles—will depend in large measure on whether the temperature to which cooling has been carried is suitable. For each type of glass there is a narrowly restricted range of temperature to which each pot of the given type should be cooled before withdrawal. A quick and reliable method of measuring temperatures s, therefore, of the first importance. In the optical-glass work conducted by the staff of the Geophysical Laboratory during the period of the war, much attention was given to the matter of determining what methods would meet the requirements. This article will deal with these investigations and with the application of the results to actual practice at various plants.

At the time that the work of the Geophysical Laboratory was begun at the Bausch and Lomb plant, each melting furnace was equipped with a thermocouple, of which the elements were platinum and an alloy of platinum and rhodium. The elements were inserted in tubes set in the back walls of the furnaces and so placed that the position of the thermojunctions was nearly flush with the inner, or heated, side of the rear walls and a little above the level of the top of the pot. Leads were brought to a direct-reading instrument conveniently placed for observation by the furnace men, and regulation of temperatures was dependent on these readings. Although the thermocouples were protected from contamination by tubes of dense and apparently impervious porcelain, it was recognised that their readings were not entirely reliable. Later work showed that the unreliability was greater than had been supposed. It seemed that, for constant use, a pyrometer of the Morse or Holborn-Kurlbaum type would meet the requirements much better than thermocouples, and an instrument of this design was obtained from the Leeds and Northrup Company.

This instrument consists essentially of a telescope with a small incandescent-lamp filament placed in the front focal plane of the eyepiece. The telescope is directed at the object of which the temperature is required and an electric current is sent through the lamp filament. The strength of the current is regulated by a rheostat until the brightness or intensity of illumination of the filament matches that of the object sighted upon. The strength of current is then read upon a milliameter, and the corresponding temperature is obtained from an empirical calibration table, which is supplied with the instrument. For measuring very high temperatures, the degree to which the heating of the filament would have to be carried to match the luminosity of the furnace or other object would be likely to produce such changes in the filament as would affect its calibration and shorten its life. Therefore, the instrument is provided with an absorption screen, which may be readily inserted between the lamp filament and the object of which the temperature is to be measured, and which cuts down the intensity of radiation from the latter. Naturally, a separate calibration table must be used when the screen is inserted and the sensitiveness of the instrument is greatly diminished. The limit at which it is considered safe to make frequent use of the instrument without the absorption screen is about 1,400 deg.; and as the accurate determination of temperatures much higher than this is seldom necessary in optical-glass furnaces, the use of the screen may generally be dispensed with.

According to the Stefan-Boltzmann law, the complete emission of what is known as "black body" is proportional to the fourth power of the absolute temperature.‡ From this, it follows that the brightness of a luminous object changes very rapidly with the temperature and that comparatively small differences of temperature (as small as 2 deg. or 3 deg.) may readily be perceived. This fact is of great importance in the practical application of the instrument.

In order to obtain a trustworthy foundation for the use of this instrument a rather thorough exploration and study of furnace temperatures was carried out by means of devices to be described. The first information sought was as to the reliability of the calibration table; to obtain this it was necessary to use a device that would give "black-body radiation." A "perfectly black" body is a perfectly absorbing body and emits radiation whose intensity is a function of the temperature alone. Most substances are of such a nature that when they are heated until they become luminous the intensity of their radiation is dependent upon an emissivity factor, the effect of which is such that two bodies at the same temperature may appear unequally bright. Naturally a substance with a surface possessing the power of reflection will send to the eye reflected rays proceeding originally from colder or hotter objects adjacent to it, and to a proportional degree will fail to send forth the luminous rays corresponding to its own temperature. A good example of an almost perfectly reflecting body is a highly polished metallic mirror. Though cold itself, it may reflect an image of the sun, for instance, representing a temperature of, say, 1,000 deg. and (if the surface does not become tarnished) may reflect the image of a cold and black substance near by and fail to send out its own proper radiation. On the other hand "black-body radiation" is given out by a substance with a surface that possesses no reflecting power and therefore absorbs all radiation falling upon it.* No substance fulfils this condition perfectly, but the requirements may be met satisfactorily by heating uniformly throughout its length a long tube of poorly reflecting material, closed at one end, so that all rays proceeding from the bottom, whether they originate there or are reflected from another part of the tube, correspond to one and the same temperature.

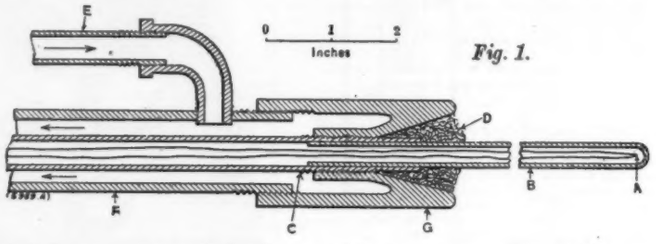


Fig. 1.

To meet the required conditions we used a porcelain tube about 1 m. long, that had an orifice of 18 mm., and was stoppered at one end with clay. This tube was inserted into the furnace and the far end was allowed to rest upon the rim of the glass pot until it became well heated. The optical pyrometer was then sighted through the orifice upon the clay plug at the far end, and a reading taken. A new and reliable thermocouple of platinum and platinum-rhodium was then inserted into the tube and readings of electromotive force were taken with a direct reading millivoltmeter. These readings, with the necessary cold-junction correction were believed to represent true temperatures, and were taken as the standard of reference. Thus tested, the temperatures given by the calibration tables for this instrument were found to agree surprisingly well with true temperatures. Some of the results are given in Table I. Later tests with other instruments indicated that this instrument was somewhat exceptional and that not equal care in calibration had been used in all cases.

Table I.—*Test of Optical Pyrometer by Comparison with Thermocouple Readings for Black-Body Radiation.*

Optical Pyrometer.	Thermocouple.	Difference.	Optical Pyrometer.	Themrocouple.	Difference.
deg. C.	deg. C.	deg. C.	deg. C.	deg. C.	deg. C.
1,122	1,126	−4	1,392	1,390	+2·0
1,076	1,080	−4	1,392		
1,022	1,022	0	1,389	1,389	0·0
1,246			1,371		
1,248	1,246	+2	1,366	1,365	+3·5
1,250					

The next matter on which information was desirable was that of the degree of agreement of temperatures as indicated by readings on the furnace walls with true temperatures; that is, to ascertain whether the radiation given out by the heated walls corresponded with black-body radiation, or whether reflections from the somewhat glazed surfaces of the refractory lining would cause significant departures from correct results. To obtain this information the furnace temperatures were explored with a specially constructed device, by which a thermocouple could be brought to any desired spot and readings obtained, and to compare these readings with the results obtained by sighting the pyrometer on the adjacent wall. The device, shown in Fig. 1, consisted of a water-cooled iron tube C (or assemblage of tubes), 9 ft. or 10 ft. (2·74 m. or 3·04 m.) in length, through the inner orifice of which the compensating leads of a thermocouple were carried. The thermocouple proper (consisting of platinum and platinum-rhodium) extended into a porcelain tube B, 35 cm. long, that projects beyond the water-cooled part. Fig. 1 shows the terminal portion of this device. The thermojunction is shown at A; in the water-cooled part the wires are connected with compensating leads of alloys of which the thermoelectric force over the range of temperature here used, is very closely equivalent to that of the platinum and platinum rhodium wires of the thermocouple, so that no appreciable error is introduced by subsidiary currents set up at the junctions. Their use obviates the need of carrying the platinum and platinum-rhodium wires back 10 ft. or 15 ft. (3·04 m. or 4·57 m.) to the meter. The thermocouple wires are insulated by porcelain capillaries (not shown) and the compensating leads by glass tubes. Asbestos wool D is packed around the porcelain tube to hold it in place and also to serve as a heat insulator and prevent a too severe temperature gradient where the porcelain tube B enters the iron tube C. The iron tube C, supply pipe E for the water-circulating system, and the return pipe F, extend back to the outside of the furnace, where hose connections are made to pipes E and F and a bushing is fitted to the tube C, through which the leads are carried. The fitting G by which the various parts are held together and kept in position was the only special construction required. This device had to be carefully handled and was not adapted for constant use, but it served the purpose for which it was devised and gave the required information. One of the first purposes for which it was used was to ascertain the distribution of temperatures from the front to the rear of a furnace in which a pot of glass was being held at fining temperature. The results are shown in Table II and Fig. 2.

Table II.—*Distribution of Temperatures in a Furnace under Fining Conditions.*

Distance from Front Face of Tuille.	Temperature.	Distance from Front Face of Tuille.	Temperature.
ft.	deg. C.	ft.	deg. C.
0·5	1,222	3·5	1,396
1·0	1,273	4·0	1,403
1·5	1,287	4·5	1,403
2·0	1,365	5·0	1,403
2·5	1,373	5·5	1,398
3·0	1,386	6·0	1,395

A comparison of temperatures as determined by the exploratory thermocouple and by the optical pyrometer showed that the interior walls of the furnace gave radiations that agreed to a very satisfactory degree with black-body radiations at the temperatures at which most of the furnace operations are conducted. The results of the determinations are given in Table III.

Table III.—*Comparison of Furnace Temperatures as Read by Exploratory Thermocouple and by Optical Pyrometer.*

Thermocouple Reading.	Pyrometer Reading.	Difference in Readings.	Thermocouple Reading.	Pyrometer Reading.	Difference in Readings.
deg. C.	deg. C.	deg. C.	deg. C.	deg. C.	deg .C.
1,320	1,322	+2	1,273	1,274	+1
1,315	1,320	+5	1,398	1,397	−1
1,311	1,320	+9	1,398	1,397	−1
1,309	1,312	+3	1,411	1,413	+2
1,278	1,282	+4	1,412	1,413	+1

The very close agreement shown is doubtless due, in some measure, to a counterbalancing of errors, as the methods used were not of the degree of precision indicated by these figures. We believed, however, that the necessary dependability of readings at these temperatures by the optical pyrometer was established. At lower temperatures the agreement was less perfect. At a temperature of 1,000 deg. or 1,050 deg., the readings taken by the optical pyrometer on the rear wall were likely to be as much as 40 deg. or 50 deg. too high, and might be even more in error. This was probably to be ascribed to departure from theoretical black-body conditions. The rear wall of the furnace probably receives and reflects radiations from hotter regions adjacent, such as the cap on which the flames play or from the flames themselves, and a source of error is thus introduced. It was noticeable that when the temperature was not very high the parts of the rear and end walls that are immediately adjacent to each other were likely to appear of unequal brightness, though there could hardly be much actual difference in temperature.

These investigations supplied sufficient data to enable us to use the instrument with confidence during the operations of melting and fining. It was therefore used daily as a substitute for the thermocouples, though the latter were still considered useful to a certain extent when properly controlled by the pyrometer. It was necessary, however, in order to use the thermocouples at all, to keep a constant check upon their readings.

* Paper to be discussed at the meeting of the American Institute of Mining and Metallurgical Engineers, at Chicago, September, 1919.

† Petrologist, Geophysical Laboratory, Carnegie Institution of Washington.

‡ R. W. Wood, "Physical Optics," 614. 1911.

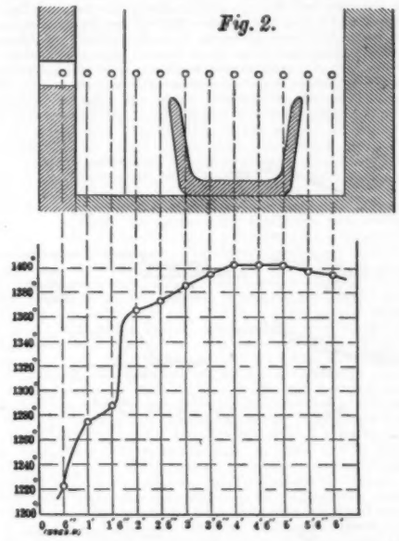
* For a more complete discussion of the laws of radiation and absorption see, for example, "Physical Optics," by R. W. Wood (1911), especially pp. 591 and following; or "A Text-book of Physics," edited by A. W. Duff (1913), pp. 279 and following.

Not only were their indications always too low by 100 deg. to 150 deg., but the error was not constant; there were likely to be gradual fluctuations each day. No investigation was made into the reason for this, but the supposition was that the fluctuations were to be attributed to contamination by the combustible gases or by material volatilised from the melts.

The furnace men were instructed in the use of the optical pyrometer, and a number of them showed considerable skill, so that we felt confident that during the night shifts the pyrometer would be properly used for regulating or maintaining temperatures. Immediately following its introduction, two gratifying results ensued. The occasional pots of milky glass ceased almost entirely and the losses from leakage of pots were almost eliminated. We think these results were due to the better knowledge of temperatures than was possible before, and to the ability to keep the temperatures where wanted.

Our experience with the optical pyrometer at the Bausch and Lomb plant caused us to install similar instruments at the plants of the Spencer Lens Company, at Hamburg, New York, and of the Pittsburgh Plate Glass Company, at Charleroi, Pa., when the work of the Geophysical Laboratory was extended to these plants. We felt it advisable to check the calibration of the new

Fig. 2.



instruments, as so much depended on their correctness. The results were not as favourable, upon the whole, as with the first instrument.* The data obtained in one case are given in Table IV. In this instance we did not use an exploratory thermocouple and therefore were not able to obtain as full information regarding the distribution of temperatures, but the method employed was adequate for the main purpose in view. It consisted of inserting into the furnace a long porcelain tube, stoppered with clay (similar to that already described), so that the closed end was over the centre of the pot; of reading temperatures with the optical pyrometer sighted through the tube upon the stopper (which corresponded to a black body) and also upon the furnace wall back of the pot; and of comparing these with readings obtained by a new and tested thermocouple introduced into the tube. These readings were taken under conditions that were probably rather less favourable than those ordinarily met in similar testing work in a commercial establishment; that is, they were made during the pressure of other duties and at a time when the demands upon furnace capacity forbade much delay and made it undesirable to attempt to hold the temperatures exactly constant during each set of readings. The degree of precision attained was, therefore, considerably less than would be possible under laboratory conditions. but the results may be taken as fairly representative of what may be easily realised in practical work, and they are therefore given in some detail. Two observers, A and B, worked in conjunction.

A porcelain tube, 39 in. (1 m.) long, was inserted through the small opening in the tuille and rested on the empty pot. The distance to the end of the tube from the outside of the tuille was 37 in. (93·9 cm.) and the distance of the thermojunction from the outside of the tuille was 33 in. (83·8 cm.). The cold junction of the thermocouple was in ice water and the readings were taken by a direct-reading millivoltmeter. Table IV shows that the readings of the optical pyrometer were in general 20 deg. to 30 deg. low; 25 deg. was adopted as representing the error with a reasonable degree of closeness.

A calibration of this kind is not very difficult and should always be carried out when a new instrument is put in service. Without this calibration, it may be possible to use the instrument empirically and get reproducible results, when all the conditions are kept constant, but the object should be to determine the true

* From a mechanical standpoint also these instruments were defective in a number of respects, and this caused us a good deal of annoyance and trouble. Later instruments have been considerably improved.

TABLE IV.—*Data Obtained in Calibration of Optical Pyrometer.*

No.	Thermo-couple Reading.	Optical Pyrometer Reading.	Observer.	Part Sighted on with Optical Pyrometer.	Average of Optical Pyrometer Readings.	Error of Optical Pyrometer.
	deg. C.	deg. C.			deg. C.	deg. C.
1	1,046	1,028	B	Inside of porcelain tube		
		1,028	B	Inside of porcelain tube		
		1,025	A	Inside of porcelain tube		
		1,028	A	Inside of porcelain tube		
		1,026	A	Rear wall of furnace ..		
		1,022	A	Rear wall of furnace		
		1,026	B	Rear wall of furnace		
		1,028	B	Rear wall of furnace	1,027	19 low
2a	1,103	1,076	A	Inside of porcelain tube		
		1,076	A	Inside of porcelain tube		
		1,066	B	Inside of porcelain tube		
		1,076	B	Inside of porcelain tube	1,074	28 low
2b	111,0	1,082	B	Rear wall of furnace		
		1,082	B	Rear wall of furnace		
		1,087	A	Rear wall of furnace		
		1,085	A	Rear wall of furnace	1,084	26 low
2c	1,110	1,087	B	Inside of porcelain tube		
		1,089	B	Inside of porcelain tube		
		1,092	A	Inside of porcelain tube		
		1,089	A	Inside of porcelain tube	1,089	21 low
3a	1,189	1,155	B	Inside of porcelain tube		
		1,157	B	Inside of porcelain tube		
		1,154	A	Inside of porcelain tube		
		1,161	A	Inside of porcelain tube		
		1,161	A	Inside of porcelain tube		
		1,152	A	Inside of porcelain tube	1,157	32 low
3b	1,189	1,161	B	Rear wall of furnace		
		1,161	B	Rear wall of furnace		
		1,156	A	Rear wall of furnace		
		1,156	A	Rear wall of furnace	1,159	30 low
4	1,225	1,200	B	Inside of porcelain tube		
		1,208	B	Inside of porcelain tube		
		1,216	B	Inside of porcelain tube		
		1,219	A	Inside of porcelain tube		
		1,219	A	Inside of porcelain tube		
		1,223	A	Inside of porcelain tube		
		1,226	B	Inside of porcelain tube		
		1,228	B	Inside of porcelain tube		
		1,219	B	Inside of porcelain tube		
		1,221	B	Rear wall of furnace		
		1,221	B	Rear wall of furnace		
		1,219	A	Rear wall of furnace		
		1,216	A	Rear wall of furnace		
		1,219	A	Rear wall of furnace		
	1,237 Av., 1,231				1,218	*13 low
5	1,248	1,212	B	Inside of porcelain tube		
		1,219	B	Inside of porcelain tube		
		1,216	B;	Inside of porcelain tube		
		1,223	A	Inside of porcelain tube		
		1,226	A	Inside of porcelain tube		
		1,228	A	Inside of porcelain tube		
		1,225	B	Inside of porcelain tube		
		1,221	B	Inside of porcelain tube		
		1,224	B	Rear wall of furnace		
		1,224	B	Rear wall of furnace		
		1,226	A	Rear wall of furnace		
		1,223	A	Rear wall of furnace		
6	1,316 1,323	1,223	A	Inside of porcelain tube	1,222	26 low
		1,298	B	Inside of porcelain tube		
		1,292	B	Inside of porcelain tube		
		1,295	B	Inside of porcelain tube		
		1,285	A	Inside of porcelain tube		
		1,300	A	Inside of porcelain tube		
		1,302	A	Inside of porcelain tube		
		1,297	A	Rear wall of furnace		
		1,300	A	Rear wall of furnace		
		1,306	B	Rear wall of furnace		
		1,304	B	Rear wall of furnace		
	1,316 Av., 1,318				1,298	20 low

* The inconsistency of this result with the others of the series is evidently due to variations in the temperature of the furnace while the readings were in progress.

temperature values. It is only by means of such information that comparisons may be made with other establishments or that reproducibility may be secured when a change of furnace construction is made or a new working procedure is put into effect. Such a calibration is necessary in order not only to check the manufacturer's calibration, but also to determine whether the furnace walls indicate a temperature that correspond to that of the pot.

There is probably some change in the latter respect with length of service of the lining. A new lining is likely to have less reflecting power and to give truer readings than one that has been in service for several months and has become somewhat glazed. Moreover, the calibration of the pyrometer itself may change. With several instruments that we were using, the current required to produce a given intensity of filament luminosity changed gradually with use. For these reasons it is essential to make occasional recalibrations of the instruments in order to be able to place reliance upon their indications. The most troublesome part of such a calibration is sighting through the long porcelain tube upon a rather small area at the end. Naturally there is likely to be some variation in the results, and therefore sufficient readings should be taken to lessen the error. To match the luminosity of the filament with that of a large object, such as the furnace wall, is comparatively easy, and in a series of such readings the difference between the highest and lowest should seldom exceed 5 deg. or 6 deg. Different observers also should agree closely in their readings. Unless extraordinary demands are being made upon furnace capacity, which will forbid keeping the furnace out of operation for any considerable period, it will usually be possible to hold the temperature steady during a set of readings, which will aid greatly in giving consistent results. If a laboratory is available, in which an electric resistance furnace forms part of the equipment, the work of calibrating the lamp may be considerably facilitated, as the necessary apparatus may be set up in more convenient form and more constancy of temperatures may be maintained. In order to obtain black-body conditions under such circumstances we used, in some of our calibration work, baffles so disposed around the orifice of the furnace as to cut off from the chamber into which the instrument was sighted practically all radiations from regions of lower temperature.* The true value of the temperature within the chamber was given by a thermocouple. It should be noted that such a method of calibration gives results that apply to black-body conditions only, and that for practical use it is still necessary to determine to what degree the walls of a given furnace fulfil these conditions.

The use of the instrument in daily work hardly requires extended description. During a large part of the time that a pot of glass is in the furnace the temperature should be maintained at a constant high level, usually about 1,400 deg. C., and all that is required is that the pyrometer is used often enough to maintain the constancy of temperature. Later, in the final stages of stirring the fires turned off and the temperature is allowed to drop. When a certain temperature is reached (which will vary with the type of glass) stirring is stopped and the pot is removed. It is of great importance that this be done at the proper moment, and the optical pyrometer is well adapted for following the temperature of the cooling glass. A few minutes before the end of operations, an extrapolation is made on a plot of the cooling curve to the required temperature and the corresponding time for removal is thus determined. A precaution that should be kept in mind is to observe some definite rule as to the part of the surface of the glass upon which readings are taken, as there are noticeable differences in brightness over the surface during the final stages of stirring. A good plan is to sight upon the area immediately behind the stirring rod, as the movement of the rod through the glass brings hotter material to the surface and the area mentioned is likely to give the brightest glow.

Although the paper has referred more especially to the procedure adopted when open pots are used, the same principles apply to covered pots. With these the arrangement is such that in sighting at the interior wall of the pot the reading is even more likely to correspond to that of a black body and to represent the temperature of the melt than when the wall back of the pot is sighted upon, as is done when open pots are used. There is a little uncertainty as to the effect upon the readings produced by the volatilised sublimates, but it does not seem that they should be a factor of significance. It is only as these fumes escape into the open air and are condensed that sighting through them should have a noticeable effect upon the readings, and even then they are so tenuous that it is doubtful whether the effect is appreciable. Moreover, they often come out in such a manner that it is possible to sight under or over them rather than through them.

Some workmen may be found to whom the regulation of temperatures by means of an instrument of this kind may be entrusted. Such operations as plotting a temperature-time curve of a pot of cooling glass require some special ability, but the procedure may be simplified by having sheets of co-ordinate paper prepared, with the hours of the day in which are printed along the bottom and the degrees of temperature are at the side. Nevertheless, the superintendent or foreman must exercise close supervision to get the best results. This, however, is true of all steps in the making of optical glass.

TREATMENT OF LOW-GRADE NICKEL ORES.—The large nickel refineries of the United States depend for their raw material, the nickel-copper matte, essentially upon the Sudbury Mines of Canada and upon New Caledonia. Nickel ores had not been smelted in the United States since 1909. During the war some low-grade nickel-ore processes have been worked out or tried, at any rate, by C. W. Davis, at the Golden Station, California, of the Bureau of Mines; the processes are described in the July issue of the *Journal of Industrial and Engineering Chemistry*. The experiments were made with two ores, an iron silicate from Webster, North Carolina, containing nearly 1 per cent. of nickel together with aluminium, calcium, magnesium, and a sulphide of iron and other metals, containing 3·7 per cent. of nickel, from Chichagof Island, Alaska. The metallurgical treatment of the silicate, it is found, would hardly pay at present; reduction and subsequent leaching with dilute sulphuric acid might, however, answer if the iron content of the ore were lower than the 22 per cent. in the ore experimented with. The sulphide ore from Alaska might be treated with nitre cake, if the price should remain favourable; the roasted tailings would first be submitted to flotation, then be reduced with charcoal, roasted with the nitre cake and extracted with water, the nickel to be deposited electrolytically or by lime, after removing the iron by means of calcium carbonate. An alternative process proposed is to dissolve the sulphide in nitric acid recovering the nitrous vapour by absorption in water, and to extract the nickel nitrate with water. Neither of the two processes looks very promising; the latter in particular would only have a chance with a fairly complete recovery of the nitric acid. But the nitric acid industry has altogether been reformed during the war, and low-grade ores in general have risen in value.

* See "Methods of Measuring Temperature," by Ezer Griffiths (1918), 116, or "Measurement of High Temperatures," by G. K. Burgess and H. Le Chatelier (1912), 240.

THE GENERAL PRINCIPLES OF THE DEVELOPMENT AND STORAGE OF WATER FOR ELECTRICAL PURPOSES.*

By J. W. MEARES, Member.

(*Concluded from page* 224.)

Lay-out of Hydro-Electric Schemes.—With a steam generating station the main considerations in fixing a site are facilities for condensing water and for fuel delivery and ash removal; none of these operate in the case of hydro-electric plant, which must be placed where the ground admits, and designed to suit it. Thus it may happen that a high fall cannot be developed conveniently as a single station, but can be utilised in the form of two stations in series, the tail water of the one discharging into the headworks of the next. This has been done at the two Santa Ana Creek stations at Redlands, California; and in the small development at Darjeeling, India, which the author carried out in 1896, the method has been used for subsequent extensions. Fig. 4 shows the varieties of hydraulic lay-out met with in practice, as described in the following notes.

High Head Lay-out.—High-head schemes are necessarily located in mountainous country, and are generally fed from torrents of small volume, liable to heavy flood and consequently bringing down much mud as well as gravel and large stones. Even if the headworks have a dam it is generally necessary to have settling tanks and a forebay, in order to prevent damage to the wheels from foreign matter travelling at high velocity. In order to get the most suitable fall with as short a length of pressure pipe as possible, it is almost always necessary to carry the water along the hillside for a considerable distance in an open channel (Fig. 4*a*), generally of artificial construction, though occasionally merely a cutting in earth. This will be dealt with subsequently, so far as the design of the canal, channel or flume is concerned. The channel offers a weak link in the chain, and duplication is impossible, though occasionally two or more separate sources of supply may be tapped by different routes. To allow for fluctuations of load (apart entirely from the question of settling tanks) a forebay at the head of the pressure pipes is essential, unless water is so plentiful that an excess is always running to waste at that point. The forebay must be of such capacity that it will supply the excess water, over and above what the supply channel brings, at the time of peak load, or in the case of sudden heavy loads (*e.g.*, short circuits) thrown on the station. If the forebay is too small, and runs out even momentarily, air will get into the pipes and water hammer will probably follow when they refill.

Thus if the channel can deal with a steady load of 2,000 kw., and the peak load averages 2,500 kw. for 2 hours, there must be at least 1,000 kw.-hours stored in the forebay. On 1,000 ft. head this amounts to about 56,000 cub. ft. This amount, however, is of no practical use as a reserve against a temporary breakdown in the channel or at the headworks, and wherever possible a scheme of this nature should have enough storage at the pipe head to tide over at least a few hours' stoppage from such causes. For this much greater capacity is necessary, and it may not always be possible to provide it. If the ground will allow no more than a regulating forebay, a reservoir must be constructed elsewhere, and the nearer to the pipe head the better. If, however, large-scale storage by means of a dam is possible it will almost always necessarily be either up-stream of the headworks or at them, and the chances of a break in the flume must be risked. Large reservoirs, constructed by means of dams, can obviously only be located where the ground offers natural facilities, i.e., at a comparatively narrow neck in a valley, which opens out above and does not rise steeply. Where comparatively small storage is required more latitude is found. In some cases of steep ground it is possible to locate the power-house so near to the headworks, even with high heads, that the water can be carried in pipes the whole way, without an open channel (Fig. 4*b*). Here the risk of breakdown is a minimum. An intermediate case between these two extremes is where the distance from reservoir or headworks to power-house is considerable, but a channel cannot be constructed owing to the slope of the ground. Generally the steep fall will be at the lower end of the pipe line, and the upper reaches will fall very little. In America the usual method of dealing with such problems is to use wood stave pipes for the upper part of the pipe line, with a surge tank at the junction of these with the steel pressure pipes, where the steep fall begins (Fig. 4*c*). The surge tank consists of a reservoir, elevated to the level of the water where it enters the stave pipes, connected by a large pipe (or separate pipes) to the junction. It not only serves as a regulating forebay, giving the water in the comparatively level upper section time to alter is velocity, but also it takes up and relieves all jars that might damage the weaker sections above it.

Medium-Head Lay-outs.—Medium heads will generally be developed either from actual waterfalls or rapids in rivers, or from rivers near the base of mountains where the volume is great and the slope comparatively small. Higher up-stream it is generally possible to utilise a high head at less cost, even though a large volume may be available. Where many rapids occur in a short length of bed it may be possible to pipe the water direct from the stream to the power-house (Fig. 4*d*), with a forebay interposed to prevent detritus getting into the pipes. In several American schemes either the whole power house is located at the bottom of a shaft cut down vertically in the rock behind the fall (Fig. 4*e*), or the turbines are placed in such a shaft and operate generators on the surface. Where there is an actual waterfall, as in many of the largest undertakings, it is seldom necessary to carry the water far to the forebay. Sometimes the pressure pipes can be led directly into the reservoir (Fig. 4*f*) or into a forebay constructed immediately above the fall; a short canal at most is required, and as it must be of large carrying capacity there is a great saving in such a natural fall.

Where the river has a considerable bed slope, or rapids, it may be necessary to carry the water for miles in a canal (Fig. 4*g*) in order to accumulate a few hundred feet of fall; and if an earthwork canal is impracticable an artificial flume is required, which adds both to the capital cost and to the liability to breakdown.

As the head decreases, and the volume of water increases, not only the flume but also the pipes increase in size, so that carriage to site often becomes a difficult and expensive problem where the installation is some distance from the railway. Occasionally a medium-head plant may be worked directly from a reservoir behind a high dam (Fig. 4*h*), but in such cases there will obviously be very large variations of head to contend with, sometimes from full head to none at all; sometimes—in fact, generally—such a reservoir will have been built primarily for irrigation purposes, so that beyond a certain minimum the flow is strictly regulated according to season. This detracts from the commercial value of any such scheme.

Low-Head Lay-outs.—Slow-running rivers and canals, with a small bed slope and no falls, cannot ordinarily be used for power purposes, as it is not possible to develop

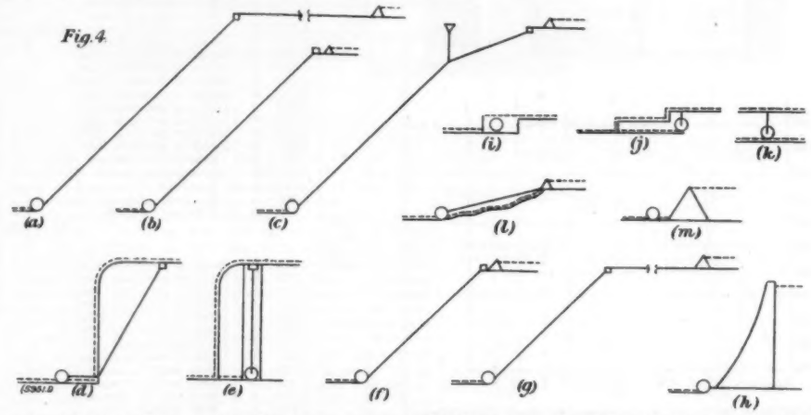


Fig. 4.

even a low fall without the risk of flooding the surrounding country above the dam; while the rise and fall of both head and tail waters, not necessarily to the same extent, further complicate the problem. Even where a small fall exists or can be made, these factors complicate the design.

In the case of irrigation canals, falls of from 3 ft. to 10 ft. are not uncommon, and can be developed by taking a feeder channel as a by-pass to the power-house, continuing as the tail race back to the canal below the fall (Fig. 4*i*). Sometimes a subsidiary canal (generally in the form of a tail race) will enable two neighbouring falls to be combined so far as the turbines are concerned (Fig. 4*j*). Larger heads, but still of the low type, may occasionally be developed, where irrigation requirements permit, by discharging part of a high-level canal through turbines to a low-level canal (Fig. 4*k*). All irrigation canal projects suffer from the disadvantage that an occasional closure is necessary—whether for purposes of repair, or because the water is not required, or because it is more urgently required elsewhere.

In the case of rivers, low falls may be developed on the lines already described for medium falls (usually a Fig. 4*l*)—always bearing in mind the ever-increasing size of channels and pipes as the fall decreases. In addition there are various schemes in which a dam is placed across a river not so much with a view to storing water as for the purpose of obtaining head. Here the water is fed directly from the dam to the turbines (Fig. 4*m*), which in some cases are placed inside a hollow dam.

Great variations in the level of the head and tail waters are often a feature of low-head river developments, and floods are a serious menace. In some cases, *e.g.*, at the station of the Portland Railway Light and Power Company, Oregon, and at Bhatghar Dam plant in Bombay Presidency, double turbines are installed, one for the maximum head and the second for the reduced fall. Flood gates, as used in irrigation canal headworks, are required to deal with abnormal rises.

Headworks and Clear Water.—There is always present the liability of bringing down mud and debris from the source of supply to the turbine wheels, though in the case of canals this is not of great importance from the point of view of power development. This liability increases with the head, as torrents take the place of larger rivers, and its effect on the wheel buckets also increases with the head and the spouting velocity of the jet or nozzle. Even the finest grit under a head of 1,500 ft. or 2,000 ft. is most destructive, and loss of efficiency soon results from worn nozzles.

Where the headworks have a considerable dam there is no danger from stones or heavy matter except that their deposition will reduce the capacity of the lake; but in hill torrents this in itself is so serious a matter that high dams would seldom be justified. Such a lake could only be cleaned out at great expense, though undersluices may enable the debris to clear itself if there is enough water to spare and if the lake is only of moderate size. If, however, such a dam is necessary it will sometimes pay to put another and smaller one further up-stream, simply as a means of arresting the silt for a few years. The capital charges would generally be less than the cost of periodical cleaning out. With lower velocity in the stream such dams are often practicable, though not necessarily at the point where the water is tapped off.

On High and Medium Heads.—Generally speaking, in the case of high and medium-head plants, a low diversion dam is all that is necessary, sufficient to ensure the possibility of getting the water into the channel or pipe under normal conditions, and also to protect the stream at this point from scouring out the channel and endangering the supply in times of flood. Cases have occurred within the author's experience where a few days' abnormal rainfall have lowered the level of a stream bed 30 ft. or 40 ft. For protecting the banks above and below the headworks boulder crates, made up of large boulders enclosed in a framework of heavy-gauge galvanised wire, have been found invaluable in every sort of river training works. Cases will sometimes be found where a permanent dam is not necessary, the natural lie of the ground alone ensuring the supply. Timber dams are sometimes used in America for levelling the bed.

In the absence of a dam, whether the water is taken direct into pipes or into a channel—but more especially in the former case—arrangements must be made at the headworks for catching all debris. Generally there will be a succession of screens or trash racks through which the water passes to a small tank, in which any heavy matter coming through will deposit. This will need constant cleaning out, and should (in the absence of other reserve) be in duplicate. Nothing but fairly fine silt should pass beyond it. If there is no open channel this tank should be large enough to remove even such silt as will deposit readily, or there should be an adjoining settling tank for this purpose. Where there is an open channel there will always be the liability of further debris being collected along it, and a forebay is necessary at the point where the pipes take off; sometimes the lie of the ground makes it convenient to put intermediate silt tanks along the route. All these should be designed for rapid clearance at several exits, controlled by gates of substantial size. By sloping the floor from all points towards the exits the flow may to a great extent be utilised to carry off the deposited mud. The size of these settling tanks should be such as to reduce the normal velocity of flow to a few inches per second. Where there is a reservoir at the pipe head it is still necessary as far as possible to prevent the accumulation of mud in it, as a large volume will become so solid that its clearance is a matter of difficulty, and a silt trap immediately before it will assist in this direction. Where water is considerably in excess of actual requirements it is possible to allow a proportion to run off continuously at the headworks chamber, through partly open sluices, which will pass out all solid matter rolling along the bottom.

On Low Heads.—In the case of low heads the water is generally clear, as low velocity postulates a small bed slope and deposition will occur in the river itself. In any case the quantity to be dealt with is so great that artificial settling cannot be arranged for. Strainers (known in America as trash-racks) are necessary to prevent floating matter entering the pipes, and a forebay may be required to catch anything that may pass through, as well as for regulation. A long canal is seldom necessary, and the forebay will either be at the side of the fall, parallel with the river, or across it on or in a low dam. It depends on the ground whether a diverting dam or anicut is required, or whether a forebay can be opened directly into the bed of the river. In the majority of cases of very low heads the power station is built across the river, and the water flows directly through the strainers into the turbines. In America much trouble is caused by ice on such plants, both from floating blocks and from ground ice (or frazil

* Paper presented to the Institution of Electrical Engineers.

as it is called there) which forms suddenly from supercooled water where its velocity is checked at the gates. This is dealt with by steam pipes and sometimes even by explosives, and may cause complete stoppage.

Canals and Open Channels.—In the cases where a very large canal is required in connection with a hydro-electric development, the design is carried out on lines of irrigation canals, to which no further reference is necessary. On medium and high heads the channels, if required, are of a smaller order. They may vary in length from a few hundred yards up to many miles, and may be single, duplicate, or multiple. The De Sabla plant of the Valley Counties Power Company in California collects water from a number of streams by means of ditches aggregating about 100 miles in length, like an inverted irrigation system, smaller channels feeding larger ones up to the forebay.

In the case of long channels a break might only be discovered after many hours; and even if due only to an earth fall, diverting the supply without breaking down the channel, it would take time to get this cleared and the water at the forebay again. In the absence of a substantial reserve at the forebay end this would involve complete breakdown. Water-level indicators, electrically controlled, are therefore often used in these cases. In the 10-mile flume of the Columbia Improvement Company at Tacoma, U.S.A., the indicator shows every inch of rise or fall; and the large capacity of the flume itself forms no inconsiderable reserve. As a motor runs on rails above the flume little time is wasted in reaching the source of trouble.

On High Heads.—For very high heads a comparatively small discharge is required, and this will sometimes be collected from more than one source and by more than one route. Earthwork channels can seldom be constructed in these cases, and the choice generally lies between galvanised iron (for very small discharges), masonry or concrete, and timber. The first and last have the advantage that they can be carried on a structure without cutting away the ground, at least in the majority of cases. As landslips are always liable to follow the cutting of a roadway on a mountain side this is a great consideration, and an inspection path can be carried alongside or over the channel. If masonry or concrete is used, water running down the hillside behind is stopped at the channel, and either flows into it with mud and stones or sinks in and causes slips. Catch-water drains of substantial size, leading to the nearest culvert, are in such cases essential. Smaller torrents may have to be crossed on bridges, and each of these should be used to afford a discharge outlet for the water in case of accidents and for scouring. Sometimes where water is not over plentiful it will pay to divert these small torrents into the channel through a small settling tank; for, though their discharge may be negligible ordinarily, it may be sufficient in times of heavy rainfall to tide over a breakdown in the channel higher up. Furthermore, when the main stream is in flood, the intake may have to be temporarily closed owing to floating debris, &c.; whereas the flood water of small supplementary streams will probably be clear and much collection of mud in the forebay may thus be avoided. This is not always true, but is borne out generally by the author's experience.

Fairly low velocities, not exceeding 3½ ft. per second in unpitched earth channels and 6 ft. per second in other kinds, are generally necessary for the preservation of the channel.* The cross-section may be square, semicircular or trapezoidal, the latter being generally the best as giving the smaller hydraulic mean radius. In order to lose as little head as possible (although a few feet on very high heads do not really count much) the slope should be kept small. The inter-relation between slope, velocity, dimensions and the construction and condition of the channel are stated in a number of rival formulæ, none of which are universally applicable; the most useful of these have been discussed by the author elsewhere† and need not be referred to in detail here. In practice the slope is generally decided on first—from 1 in 500 for small channels, to 1 in 1,500 or so for large ones—and the dimensions are calculated to suit. It is very necessary, however, to remember that any data found by a formula dealing with a straight length of channel will need alteration where there are bends or irregularities. An opening out of the width by an extra 5 per cent. or 10 per cent., carried back to the limit of the possible afflux, may be required to prevent overflow, or a corresponding raising of the height or increase in the slope. Uncontrolled overflow would be almost certain to produce landslides and breakdowns. As, apart from faults in design, a small fall of earth may easily cause such an overflow, it is sound practice so to regulate the height of the side wall that overflow will take place most easily at places where it can do no harm, i.e., over solid rock, or into streams passed by the way, or, in the absence of these, down artificial spillways.

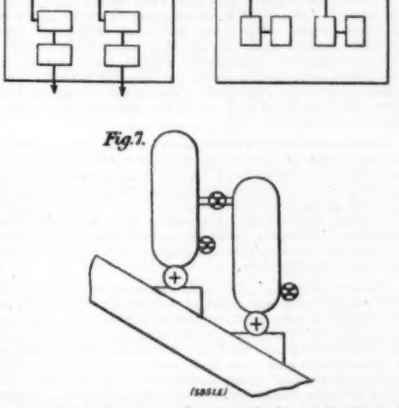
In order to prevent the channel being overfilled at the headworks a method often used is to place a diverting place in the fairway at a point near the headworks, such that any flow beyond the capacity of the channel is skimmed off and discharged back to the stream.

Where masonry or concrete channels are used most of the above considerations apply with equal force. Here it is necessary first to cut a roadway for the foundation, so that the liability to landslips and rock falls is greatly increased. Where the ground is at all doubtful cut-and-cover is necessary, and it is better to spend money on revetments to begin with, than to take the chance of bad ground holding up. It is essential to make culverts under, or preferably over, the channel for the very smallest lines of natural drainage, both for safety and to prevent the access of stones to the channel. Often it will be advisable to lay small drains down such places, with cross-collecting drains to prevent a wash-out.

In extreme cases tunnelling may have to be resorted to, for the avoidance of bad ground. It may also pay at times to tunnel through a bluff rather than go round it. Tunnelling on a large scale is also sometimes required either to join up two sources of supply in different watersheds or to lead water collected in one area to a different watershed, where a more convenient or higher fall can be obtained. There are many examples of this class of work in America and elsewhere.

On Medium Heads.—While small works on medium heads may be served by the same methods as apply to high heads, canals in earth are generally necessary. The cost of an artificial channel would generally be prohibitive over a certain size. The largest timber flume the author has seen was at Tacoma, U.S.A., and was 8 ft. square and about 10 miles long, with a fall of 7 ft. per mile. No other material could be used for a channel of this size, and timber has its drawbacks. Unless the water is running full all the time warping is certain to occur, while boring insects and rot have to be faced. The large flume of the Thelum hydro-electric works has suffered severely in this way.

Forebay Reservoirs.—Whether the forebay is mainly for regulation, or whether it also holds a considerable reserve supply, it is an important link in the chain. It must be so designed that, while acting as an efficient



surge tank, and as a regulator to deal with loads temporarily exceeding the capacity of the channel, it does not allow any foreign matter to get into the supply pipes. Coarse and fine strainers should be provided, and they should be of such breadth that the full flow required by the wheels can pass through them if the water accidentally falls low. This is often overlooked in designing. In some small installations the actual reservoir is at a little distance from the forebay or pentrough, and the two are connected by a closed pipe large enough to deal with the peak load. In such cases the reservoir performs these latter functions, while the forebay proper becomes only a surge tank.

The forebay, or forebay reservoir where these are combined should if possible be sectionalised or duplicated to admit of cleaning out; and the design should be such as to facilitate this, as suggested above for silt traps. Where the channel discharges into it, which should be at a point as far as possible from the pipe entry, there should first be a small chamber to take eddies and induce still water; this will also catch some of the residual silt, and as its walls will stop a foot or two below normal water-level only the clean overflow will pass into the reservoir proper, and not the bottom layers, except at cleaning-out times. (This of course assumes that the width of the sill is greatly in excess of the width of the channel.) The spill-way and scour valves of the reservoir should be near this point, where most of the mud will collect.

The strainer that finally ensures no foreign matter getting into the pipe requires careful thought. The obvious plan is to put it immediately behind the bell mouths of the pipe, and to close it in at the top. But there is a chance then that some part of it may eventually rust away and get into a nozzle. Repairs would be difficult without emptying the forebay and shutting down the plant, and it has been found in practice that the arrangement is not satisfactory. The alternative design, which should be adopted, is to put the strainers in the main forebay, at the entrance to a separate walled-off chamber feeding the pipe, and this chamber should be covered over. Rolling screens, operated by a winch, are useful because of the facilities they offer for cleaning. A point of importance is that the screens must be capable of passing the full flow when the forebay is nearly empty.

An emergency by-pass from the channel, also provided with a screen, should be made to discharge direct into the bell-mouth chamber. If repairs are required to the reservoir this will prove invaluable, and when the water is running clear it can be used while cleaning out proceeds. These small points of design may spell the difference between success and partial failure, though of course a good deal depends on whether clear or dirty water is generally brought in. For reasons already explained high heads need the most careful treatment. Medium heads may or may not need complicated forebays, and with low heads a plain tank is generally sufficient.

Pressure Pipes.—There is considerable diversity of opinion as to the best arrangement of pipes for feeding a number of turbines. Apart from the question of cost there can be no doubt that the ideal arrangement is self-contained units of pipe, turbine, generator and step-up transformer, just as in modern steam practice. Where very large units are involved no other arrangement is likely to be used, and on low heads no other arrangement is generally possible. Intermediate cases must, however, be discussed. Structural design is beyond the scope of this paper, but it may be stated that the diameter of a short pipe on a moderate head may be such as to give a velocity as high as $0 \cdot 1 \sqrt{(2gH)}$, or 10 per cent. of the spouting velocity. The loss of head with such velocities would soon become too great, and about 3 ft. to 4 ft. per second is a good average. On high heads, 9 ft. to 12 ft. per second in the smallest sections is about the limit used. In a good many instances pipe lines have been brought straight to the power-house, and the turbine and generator mounted over the tail race in the same alignment, as in Fig. 5. From every point of view the arrangement in Fig. 6 is preferable. In the first place, a burst pipe will be less likely to flood the power-house; in the second place the generators are on a solid foundation instead of being carried over the tail race.

On High Heads.—With very high heads comparatively small pipes of great strength are required; the locality is likely to be far from railhead, so that carriage to site is an expensive matter. It therefore pays as a rule to keep down the weight of individual loads, and to use a single pipe for each turbine. It is, however, often advisable to interconnect the various pipes at the forebay. Each pipe should be capable of being instantly closed at the forebay in the event of a bad blow-out, either by an automatic valve or by electrical control from the power-house. Each pipe must also have an isolating valve at the forebay or a gate in the forebay. Air pipes and filling valve may also be required.

Where conditions are favourable a single pipe is often used to serve two or more units by means of a receiver at the power-house, especially in the case of small plants, but this is not ordinarily recommended.

In order to reduce the thickness of the lower sections of pipe it is customary to use two or more diameters, the smaller at the bottom, and this also economises in freight where they can be nested.

Where individual pipes serve each wheel it is advisable to interconnect them at the power-house, so that in the event of a joint blowing on one pipe while another generating unit is out of service they can be cross served. This involves extra expense in isolating valves, but is generally worth it. It is not an identical proposition with the receiver.

Long lines of pipe, such as are required on high heads, require very substantial anchoring not only at the top and bottom but at several intermediate points. These also provide safe positions for expansion joints, which can be dispensed with only where the temperature variations are small or the line has many angles in it—and not always then.

Air valves are not often required, but will be where there is an unavoidable rise in the pipe line. Occasionally air cushions are provided in very long lines, to take up shocks; at the Mill Creek plant in California the pipe is 8,700 ft. long for a head of 1,950 ft., and both air valves and cushions are installed. The latter consists of duplicate cylinders for recharging at the necessary high pressure (Fig. 7).

Both main valves are first closed and the air and exhaust cocks opened. After closing them No. 2 valve is opened and the air is compressed. This process is repeated until the cylinders are fully charged.

The reduction of effective diameter due either to ordinary furring from lime, &c., or more particularly seriously to increase the loss of head. Although cleaners of the revolving turbine type can remove a good deal of this deposit, the initial diameter should be always greater than is indicated by the velocity decided on.

On Medium Heads.—There are no special points in which the pipe system on medium heads differs from that already dealt with. The pipes are of larger size, and their carriage becomes more serious unless they are built up at site, but on the other hand the locality is generally more accessible. Air valves and cushions are seldom required.

On Low Heads.—With very low heads and submerged turbines the draught tube is the only pipe required, while with somewhat higher heads there will be both pressure pipe and draught tube. With large units of plant the size of the pipes becomes very great and the internal hydraulic pressure becomes a secondary consideration. Cases are on record where an automatic gate, serving a very large pipe, was closed at the forebay and air pressure caused a complete collapse. No interconnection is usually practicable or necessary with low heads.

Tail Races.—On low-head plants the essentials of the tail race are that it shall be of ample size to give a very low velocity of discharge, and that it shall be free from eddies. A very small loss of head may be a very large percentage of the total—every inch represents 3 per cent. on a 3-ft. head—and the draught tube and tail race are just as important as the head works. Backing up of the tail water from excessive flow may be unavoidable, but bad design may increase it unnecessarily.

With medium and high heads the water has done its work when it leaves the discharge orifice, but it has considerable capacity for mischief left in it. The tail-race pit must ensure that there are no waves tending

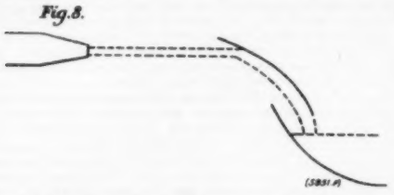
* For details see Captain Garrett's "Hydraulic Tables and Diagrams" (Longmans).

† "Electrical Engineering Practice," third edition (Spon), paragraphs 349 to 351.

to stop the free exit of the water, and it must also cushion the discharge so that the structure is not destroyed. On heads of 2,000 ft. or so the destructive effect of the spent jet is surprising, and masonry is quite unable to withstand it. Baulks of timber or cast-iron blocks, which can easily be renewed, are sometimes fixed in the pit. Other arrangements are designed to divert the direction of the discharge to strike the tail race water horizontally, by means of one or more curved vanes, when a long tail-race pit will act as an effective cushion (Fig. 8). At the Kern Canyon power station, near Bakersfield, California, this arrangement was used even where the jet was diverted below the buckets, under the full pressure of 900 ft. head. In most cases, however, the lowered jet has a free path over the tail race and spouts directly into (or across) the river below.

Conclusion.—The general description of the lay-out of hydro-electric schemes in all their many forms has made this paper unduly long without entering into any details of actual design. A word must, however, be said in conclusion with regard to cost. From the generator onwards there is no great difference in capital cost between steam and hydro-electric stations, and the cost of the power-house buildings will be comparable. The boilers, steam pipes, engines or steam turbines, condensing

Fig. 8.



plant and accessories are replaced by the comparatively simple turbine wheels and their supply pipes in the most favourable cases; but in less simple plants there is also the whole cost of the hydraulic development, channels, forebays, reservoirs and dams, to set off against the steam plant.

The working expenses—staff, management, lubricants and stores, maintenance and repairs—do not differ in principle in the two instances; practically the annual cost of fuel in the one case must be set off against the extra annual capital charges in the other. The total cost of fuel is proportional roughly to the number of units generated, and expressed in pence per unit it remains sensibly constant in any undertaking. On the other hand, the total annual costs of a hydro-electric station are practically fixed, so that the cost per unit varies inversely as the number of units generated. In both cases the capital cost, and consequent annual capital charges, vary largely with the load factor. An important difference between steam and hydraulic working lies in the fact that every unit generated by the former method costs a definite sum in cash for fuel, so that actual loss would result in selling at that figure; whereas with water power there is no such cash expenditure and any sales which will fill up hollows in the load curve without affecting the peak must be profitable at whatever rate they bring in. The common idea that water power costs nothing is true only in this limited instance. In any such comparison capital cost, cost of fuel, and load factor are the three essentials which determine whether a project can best be served by fuel or by water power.

Trade with Greece.—A great opportunity presents itself to British manufacturers and merchants in the Grecian markets to-day. During the last five years Greece has of necessity purchased her goods elsewhere, but she is ready and anxious to purchase British goods if they are obtainable at competitive prices. Any manufacturers interested in the Grecian markets are invited to communicate with The Overseas Trade Bureau, The Overseas Club and Patriotic League, General Buildings, Aldwych, W.C. 2. Some of the inquiries received include information with regard to manufacturers of an excavating dredger, carriage rubber tyres, iron gas and water pipes and fittings, balata and leather belting, &c.

The Electricity Works, Zschornewitz.—The electricity works at Zschornewitz, near Bitterfeld, were built in the year 1915 for the utilisation of the lignite deposits of the district and especially for the electricity supply of the newly-erected nitrogen products works. For more than a year the new plant has also been sending electricity to Berlin through a 110,000 volts line, 132 km. in length, and with its actual capacity of 180,000 kilovolt-amperes the steam plant ranks among the largest in existence. The chief buildings are the engine-house, which has a length of 200 m.; four boiler houses, each 80 m. long, at right angles to the engine-house, containing 64 boilers, each of 500 sq. m. heating surface; 11 cooling towers, each of a capacity of 3,800 cub. m. per hour; and 9 chimneys, 100 m. high. The eight turbo-dynamos are to give 22,500 k.v.a. at 6,500 volts. The main switches, in a special building, contain the transformers, one for each turbodynamo, which raise the tension to 82,500 volts for the nitrogen oxidation and to 110,000 volts for the transmission to Berlin; the line ends in the new transformer house of The Berlin Electricity Works, erected at Rummelsburg, near the metropolis. The line consists of three aluminium wires, 120 sq. mm. in cross-section, which are supported by iron masts, 25 m. high, spaced 250 m. apart. The Elbe River is crossed in a span of 307 m. length, carried by towers 60 m. in height; over the River Spree the line is taken in a span of 211 m. length, resting on masts of 48 m. height.

CATALOGUES.

Small Tools.—A good selection of small tools, such as knurling tools, centring drills, taper and parallel sockets and sleeves, drifts, mandrels, carriers and a variety of lathe tool holders are shown in a small special catalogue issued by Messrs. Jones and Shipman, Leicester.

Heat Treatment.—A circular explaining the location of hardening faults in workshop heat treatment comes from Automatic and Electric Furnaces, Limited, 281, Grays Inn-road, W.C. 1. It is helpful, but rather more in the style of a scientific essay than some of the earlier series of these leaflets.

Electric Furnaces.—An electric furnace made in six sizes up to 12 in. diameter, quenching baths, muffle small pouring furnaces, and a magnetic sclerometer are described and illustrated in a catalogue issued by Automatic and Electric Furnaces, Limited, 281, Gray's Inn-road, W.C. 1.

Concrete Roads.—Some useful information is given of the composition of a concrete road, with metal fabric reinforcement, in a pamphlet issued by the British Reinforced Concrete Engineering Company, Limited, Dickenson-street, Manchester. It is an experimental section, opened in 1917, of the main Dock-road, London, E., for exceptionally trying traffic.

General Machinery.—A catalogue showing representative examples of their many classes of machines is issued by Messrs. Manlove, Alliott and Co., Limited, Nottingham, including centrifugal machines, cooking apparatus, disinfectors and sterilisers, drying machines, evaporators, filter presses, laundry, oil-mill and sugar-mill machinery, sewage ejectors and pumps, and refuse destructors. A few illustrations are given in each class.

Sheet Metal Pipes.—The Standard Spiral Pipe Works, Chicago, U.S.A., send another issue of their catalogue of these pipes. They are made of strips of metal helically wound with the meeting edges folded over on the outside with a similarly folded piece interlocked The effect is to add a spiral reinforcing thread of four thicknesses of the pipe wall. The range of sizes includes pipe bores of from 3 in. to 42 in., and they are supplied black or galvanised.

Furnaces.—Designs of furnaces for calcining limestone, fireclay, &c.; continuous push type for reheating metal ingots, billets slabs, &c.; heat-treatment type with gas producer; and a gas reversing valve are described, with full line drawings in catalogues from Mr. E. Windsor Richards, consulting engineer, 65, Renfield-street, Glasgow. These are made in various sizes and designed for special work. The catalogues are simply worded and the drawings clear.

Electric Welding.—Portable machines for arc cutting and welding by alternating current are described and illustrated in very practical and lucid terms in a catalogue from the A.C. Cutting and Welding Company, Limited, 25, Theobalds-road, W.C. 1. A transformer is used, and a controllable and even heat obtained, a direct-current source of supply being sufficient. The example jobs given include boiler repairs, the straight-across fracture of an armature shaft, and the building up of worn journals for re-machining to originally designed size.

Furnaces.—The firm formerly known as J. Lord, Limited, Stockport, has been reformed under the title of J. Lord (Manchester), Limited, with head office at Lords Chambers, Corporation-street, Manchester. The intention is to specialise in the large types of furnaces and ovens for forging, shingling, re-heating, and general heat treatment. The new catalogue shows some excellent examples of these on a large scale adaptable for coal, coke, oil, gas or producer gas fuel; also an oil atomiser made in three sizes and carefully designed both for efficiency and easy cleansing.

Fuel Oil Burning.—Various methods are used for converting oil into spray before burning it for raising steam. The method which has been carried out in a large number of marine installations for some years by Messrs. J. Samuel and Co., Limited, East Cowes, is to pump the oil under pressure of 100 lb. to 180 lb. per square inch through a nozzle which rotates and breaks up the oil into fine spray spreading over a considerable surface. The catalogue deals exhaustively with the subject in all its practical bearings, and gives ample illustrations of the application to many sizes of boilers. Useful technical data and some fine illustrations of naval vessels are included.

General.—Some firms have taken to issuing general descriptions of their work in pamphlet or book form. The intention is to convey an idea of the scope and principal directions of the work with illustrations and details of machines or structures characteristic of each class. A good example of this kind of publication is to hand from Messrs. Clayton and Shuttleworth, Limited, Lincoln, a firm established in 1842 for the making of agricultural machinery. Although the firm has, in the main, followed heavy and substantial work, it turned out much of the best aircraft during the war. In such firms the staff, for the main part, are engineers, who apply themselves to specialised work as distinguished from specialists of the class who have become familiar with a particular machine without being engineers. Aircraft and steam road rollers, however dissimilar they may seem, are the product of the same kind of thought and skill. To find the two machines in one catalogue—or what may be called an introduction to the catalogue proper—is a little curious, but, in our view, not at all inconsistent. It is merely a happy illustration of the diversity of products which come from a common source of special ability. This firm has also taken up the manufacture of steel castings to 3 cwt. forgings to 20 cwt.; and stampings to 7 cwt.; for example, a clean forged crankshaft is shown, 8 ft. 6 in. long and 30 in. length of web.

Marine Engineering.—A record of war work issued by the Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne, presents a straight detailed list and summary of five years' work. Sets of marine machinery were built, fitted and delivered for 68 vessels of a total indicated horse-power of 1,346,000, including the two first-class battleships Queen Elizabeth and Malaya, 4 cruisers, 26 destroyers, 2 ice-breaking train ferries for Canada, 11 merchant vessels, and other ships of various classes. Two hundred and thirty-four oil-burning installations, 111 water-tube boilers, and turbine diaphragms of over 1,500,000 shaft horse-power were also made. In addition, 151 war and merchant ships were repaired and overhauled, including every variety of marine engineering and shipbuilding work, and involving the withdrawal of about 40 propeller tail shafts. Nothing is said as to the difficulties and strain of carrying through this programme, and it is, indeed, an almost hopeless task to convey to those not familiar with such work the severity of the trial to which all branches must have been subjected. So far as any overall estimate of the total can be formed, it seems that about 3½ times the total work of a normal busy year was steadily maintained during each of the four years 1915–18. It shows that in private organisation we have truly "national" workshops at hand, when the nation needs them, of a far higher efficiency than any State organisation has ever shown.

Protection for Silvered Glass Mirrors.—In the *Astronomische Nachrichten*, No. 208, pages 85 to 88, 1919, Dr. A. Miethe, of Charlottenburg, describes a simple process for protecting silvered glass mirrors from being tarnished by the atmosphere or by the vapours of laboratories. A solution of japan varnish in five or six times its weight of amyl acetate is poured on the mirror and run off again; the mirror is then dried. The glass should previously be cleaned thoroughly. Such a varnish coating is not new, of course. The journal quoted—which has not yet reached us—is, however, said to contain an excellent reproduction of a photograph of the moon, taken with such a protected mirror, 50 cm. in diameter, to demonstrate that the uniform varnish film had not impaired the definition of the photograph.

British Standard Specification for Steel Fishplates.—The British Engineering Standards Association, under the title, "Report No. 47, 1919," have just published a revised specification for steel fishplates. The principal differences between the new issue of the above specification and the last issue in 1914 are as follows: (1) *Provision for a Harder Fishplate.*—It appeared from inquiries made by the association that while the quality of fishplate previously specified had given satisfaction to a large body of users, a demand existed for a harder fishplate, and this has been provided for in the present edition. (2) *Bend Tests.*—The hot bend test has now been omitted, and also the cold bend test *through the bolt holes.* (3) *Omission of Fishplate for B.S. 20-lb. Flat Bottom Rail.*—The fishplate for the B.S. 20-lb. flat bottom rail is now omitted from the specification, as this rail will form the head of a new series of light flat-bottom rails ranging from 10 lb. to 20 lb. per yard, and which will shortly be issued.

The Lowering of the Water-Level in Lake Ritom.—In our issue of August 25, 1916, page 185, we gave an outline of the projected utilisation of the water power of Lakes Amsteg and Ritom for the benefit of the Swiss Federal Railways, and a year later, on page 367 of our issue of October 5, 1917, we described the most dangerous part of the scheme, the tapping of Lake Ritom, which was successfully carried out in February, 1917. A tunnel, 220 m. in length, was driven under the lake from the south and continued until a thickness of about 1·5 m. (from 1·35 m. to 1·75 m.) remained between the tunnel and the lake bottom. A vertical shaft, sunk to a depth of 35 m. on the bank of the lake, divided this tunnel into two sections, the tapping conduit proper and the discharge conduit; the sluices were at the bottom of the vertical shaft. The final breakdown of the rock left between the lake bottom and the tunnel was effected by means of charges of blasting gelatin, placed in 17 holes. This successful blasting lowered the water level in the lake by 18·3 m., from 1,831·5 m. to 1,813·2 m. above sea-level. The whole operations have since been described in No. 13 of the "Mitteilungen der Abteilung für Wasserwirtschaft," an official publication of the Swiss Waters Department, and the very fully illustrated account draws particular attention also to the peculiar changes which this fall in the water-level by nearly 60 ft. has brought about in the new lake basin. The beauty of the scenery has badly suffered, probably to an unusual extent. The former rock walls, rising directly from the water, are now fringed with ledges of flat rock, mud and detritus, so far bare, and the erosion of this new ground by the small, but periodically torrential, rivers which enter the lake, has not improved the scenery. The appearance changes from month to month, much more than formerly. The ground eroded in one spot has been piled up on other spots, actually raising the level. Big blocks of rocks remain unaffected; but the river deltas, formerly covered by the water, are visibly changing, and gorges are washed out of the detritus. One interesting peculiarity has been confirmed by the lowering of the lake level. The surface water is sweet and sustains animal life; the deeper water is poisoned by sulphuretted hydrogen which, as has now become clear, is liberated from the gypsum in the lake bed proper; the lake walls chiefly consist of gneiss.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

AERONAUTICS.

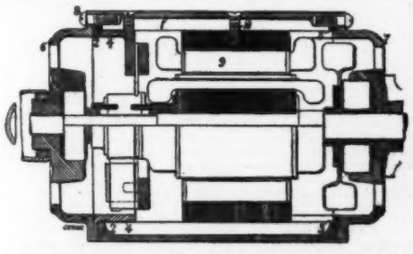
127,035. E. Young, Leeds, and The Blackburn Aeroplane and Motor Company, Limited, Roundhay, Leeds. Aerial Machines. (5 *Figs.*) March 23, 1917.—The present invention refers to an improved manufacture of a turnbuckle of the type comprising a spindle having a hole for a tommy bar, by which it can be turned, and formed at its ends with opposite-handed screw threads, and screwed into a bar or boss from which forked members proceed to which the tension wires to be tensioned

Fig. 2. Fig. 3.

are connected. 1, 2 is a tension rod formed of one piece of metal comprising two shanks, the shank 1 being formed with a left-hand screw thread and the shank 2 with a right-hand screw thread, while centrally of its length the tension rod is made with an enlarged portion with a hole drilled through it to receive a tommy bar by which the rod can be turned. 5, 5, are fork ends of the accepted or standard design, one with a right-and the other with a left-hand thread, which are on to the threaded ends 2 and 1 of the tension rod. (*Accepted June* 4, 1919.)

ELECTRICAL APPARATUS.

127,068. The Portable Electric Motors, Limited, London, and G. Fryer, London. Dynamo Electric Machines. (3 *Figs.*) May 17, 1918.—This invention relates to dynamo-electric machines. The field or stator stampings, the end bracket at one end and the brush rocker at the other are all made of the same diameter to fit within a frame bored to that diameter throughout. The brush gear is carried on a single substantial insulating ring, fastened to the annular rocker. The frame 1 of the motor is of aluminium, and of plain cylindrical form. The frame is bored to one diameter only, namely, the diameter of the internally-machined surfaces 2 and 3 of the ribs and flanges of the frame. Besides this boring, the only necessary machining of the frame is the facing of its two ends. In bore 2 fits an aluminium brush-rocker 4 of which the external pro-



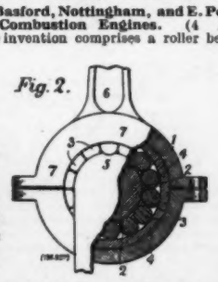
jection forms a register for the commutator end bracket 6. In bore 3 registers the pulley-end bracket 7. To effect removal, it is necessary merely to undo the three or four retaining screws 8, when the whole of the interior of the motor can be thrown open for inspection and cleaning. With the frame and its adjuncts constructed as has been described, use can be made of two end-bearing brackets of precisely identical form (though those here shown differ slightly). The stator 9 is laminated, being composed of circular punchings with internal slots, the punchings being held together independently of the frame by means of small longitudinal rivets (not shown). The stator is attached to the frame by means of three screws 10, which are spaced 90 deg. apart in order to ensure that the stator shall be assembled so as to suit the predetermined and marked, most efficient position of the brushes. (*Accepted June* 4, 1919.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

126,927. G. Brough, Basford, Nottingham, and E. Poppe, Coventry. Internal-Combustion Engines. (4 *Figs.*) February 15, 1919.—The invention comprises a roller bearing

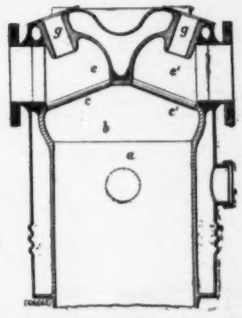
Fig. 1

Fig. 2.



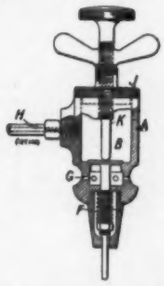
for use with the crankshafts of internal-combustion engines. According to this invention, a roller bearing for use in connection with the crankshafts of internal-combustion engines, comprises a complete annular ring 4 concentrically around the crank or crankshaft 1, a series of rolling members 3 disposed between the ring 4 and crank or crankshaft 1, and engaging with a part 2 of reduced diameter thereon, and flanges 7 integral with the connecting rod 6 or bearing supporting the crankshaft, said flanges projecting inwardly beyond the ring and overlapping the ends of the rollers for the purpose of retaining said ring and rollers in position. A recess or other equivalent means is provided for enabling the rollers to be introduced into place. The parts are so arranged that in use the rollers make contact with the interior of the annular ring and with part of reduced diameter on the crank or crankshaft. (*Accepted May* 28, 1919.)

126,662. Vauxhall Motors, Limited, Luton, and C. E. King, Luton. Cylinders. (2 *Figs.*) January 30, 1917.—This invention relates to the construction of valve ports for cylinders of the type built up of portions produced by machining from solid ductile material connected together by welding. According to the present invention, the valve port is of globular or spherical form, thus enabling a branch pipe to be disposed at any angle while still ensuring a plain cylindrical ring for engagement at the welded or like jointing surface. *a* is the cylinder barrel for an internal combustion engine cylinder. The upper end *b* forms the combustion chamber, and it takes the form of a flattened cone upon its upper surface. Within this surface two openings *c*, *c*1, are formed, and these are provided upon the outside of the cylinder with surrounding turned surfaces for the reception of the valve ports or pockets *e*, *e*1. The valve



pockets are of globular or spherical form and are produced by turning from solid ductile material. The lower side of the members *e*, *e*1, are open, the openings being provided with flat surrounding surfaces coinciding with the surfaces upon the outside of the cylinder end. The upper sides of the members *e*, *e*1, are provided with bosses *g*, which may be arranged for the reception of bushings of material suitable for co-operating with the valve spindles. The members *e*, *e*1, are each penetrated on one side by a cylindrical aperture, and into this aperture there is inserted a ring, also produced by turning from the solid. The ring *i* is firmly fixed in position in the aperture, and the valve box itself is firmly fixed in position upon the facing of the cylinder end by welding. The outer end of the mouthpiece is constructed to take a branch pipe connection, and it may be provided with a short length of pipe *k* fitted with a flange, which may be welded in position. (*Sealed.*)

127,142. G. Burton, Kenilworth, and J. T. Peckmore, Kenilworth. Internal-Combustion Engines. (1 *Fig.*) July 6, 1918.—The invention provides a valve which will automatically weaken the mixture by supplying additional air during normal running. According to this invention, the valve comprises a body communicating with the engine induction system and provided with a non-return valve for the admission of air, and a screwed rod which serves as an adjustable stop limiting the opening of the valve and also to hold the valve upon its seat when so required. The valve comprises a cylindrical barrel A. The bottom of the barrel forms a seating for a poppet valve B, the stem of which projects downwards through a guide screwing into an extension of the barrel. The valve stem may be screwed to receive a nut adjustably pressing on a light spring F, which



serves to retain the valve closed. As will be seen, the air inlets G are made in the extension of the barrel, below the head of the valve. The interior of the barrel communicates by the pipe H with the engine induction system. At the top the barrel is closed by a screw cap J, through which passes a screwed rod K. The lower end of the rod when screwed right down presses upon the valve-head B so that the latter cannot open, but by unscrewing the rod K an adjustable lift is afforded to the valve. When the engine is started the rod K is screwed down to keep the valve closed so that the mixture taken in is not diluted with air taken in through the supplementary valve. For ordinary running the rod is unscrewed to allow the valve B the desired lift, so that under engine suction the valve rises, allowing the passage of additional air. (*Accepted June* 4, 1919.)

127,107. F. E. Alford, East Dulwich, London. Radiators. (2 *Figs.*) May 25, 1918.—The invention relates to sheet metal radiators employed in connection with internal-combustion engines. According to the invention, the radiator comprises the combination with a series of water passages formed by doubling a corrugated sheet of metal upon itself, of flat metal fins or webs arranged a convenient distance apart transversely and at right angles to the length of the water passages so as to act as distance-pieces and provide extra cooling surfaces, said fins or webs having therein slots merging into enlargements through which pass the water passages and the lengths of metal interposed between said passages. The thin metal sheets *a*, *a*, are each bent back upon each other in such a manner as to form channels *d*, *d*, thereby providing passages for the cooling water. The intervening webs *b*, between the channels, lie closely against one another, and are secured in that position by soldering. The finished sheets *a*, *a*, are placed vertically side by side with a suitable space between to allow for the passage of the air. This air space in each

Fig. 1.

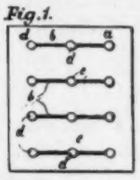
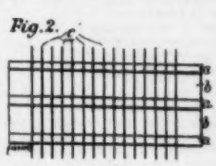


Fig. 2.



case is divided up by a series of thin metal fins or webs *c*, *c*, spaced a convenient distance apart, one above the other, and preferably in a horizontal manner. These fins or webs *c* have a series of slots merging into enlargements cut through them agreeing in position to the position of the passages or channels *d* and interposed metal *b*, and these fins or webs are so shaped as to fit closely against the two adjacent faces of the vertical channelled sheets, as shown at *c*, *c*, and are maintained in this position by soldering. (*Accepted June* 4, 1919.)

GUNS AND EXPLOSIVES.

*** 127,034. W. J. Evans, Birmingham. Machine Guns.** (4 *Figs.*) September 20, 1917.—This invention relates to machine guns of the Lewis type. In conjunction with the ordinary circular magazine *a*, which has a notched periphery and is rotatable in a horizontal plane, is mounted a fixed base *b*, formed with an aperture *c* through which cartridges *d* can be fed into the slots in the magazine from a hopper *e* detachably secured to the base. At its upper end the hopper opens out to form a receptacle from which the cartridges can pass in a single column down the part illustrated to the magazine. Adjacent to the aperture *c* is arranged a rotatable impeller *f* and a sliding shutter *g*. The impeller is intermittently rotatable through bevel wheels *h* from a shaft *i* and toothed wheel *j*, which is engaged by toothed projections disposed at intervals around a hand wheel or disc *l*.

Fig. 1.

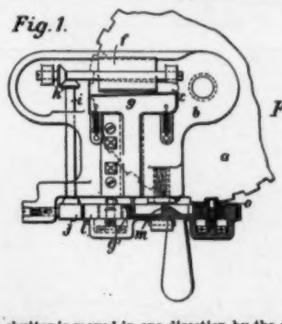


Fig. 2.

The shutter is moved in one direction by the engagement of an extension *g*1 at one end with one of an annular arrangement of cams *m* formed in a groove in one face of the disc *l*, these cams being projections in the groove which, in turn, engage the said extension. Rotation of the magazine is effected by lateral projections *o* on the disc *l*, which in turn engage the notches in the periphery of the magazine. The cycle of operations is as follows: During the angular or rotary movement of the magazine the shutter is held across the bottom of the hopper so that no cartridges can pass. After the magazine has come to rest the shutter is withdrawn and the impeller is actuated and caused by engaging the cartridges to press one down into the magazine. By the time this has been effected another of the projections *o* engages the magazine and the cycle is repeated. (*Accepted June* 4, 1919.)

127,026. Sir A. T. Dawson, Westminster, London, and Sir G. T. Buckham, Westminster, London. Ordnance-Sighting Apparatus. (3 *Figs.*) March 19, 1917.—This invention relates to sighting apparatus for ordnance carried by an aircraft, and of the kind having a crank provided with a pin which operates upon the sight arm and which can be adjusted radially in accordance with the speed of the gun platform, so

Fig. 2.

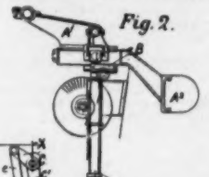
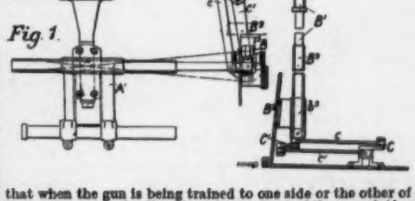


Fig. 1.

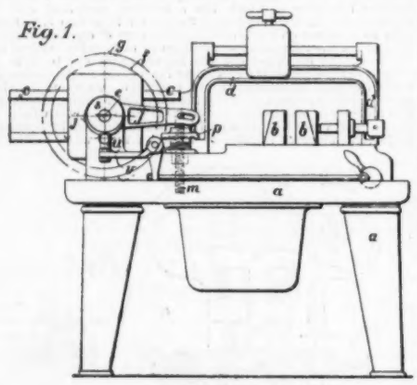


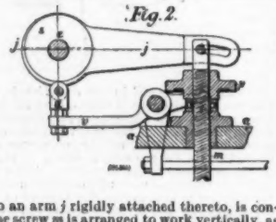
that when the gun is being trained to one side or the other of a line representing the direction of movement of the gun platform the sight will be automatically deflected to compensate for the speed of the gun platform at any particular training angle of the gun, the said crank having interposed between it and a fixed part of the gun platform a system of parallel motion linkage which serves to maintain the crank in a fixed angular position

during the training of the gun. According to the present invention, the parallel motion linkage is so constructed and arranged as to avoid a dead centre during the training of the gun. A is the sight arm which is slidably connected to a sight bracket A^1 pivoted on the gun cradle A^2. The crank B is carried by the upper end of a rod in two parts B^1, B^2, telescopically keyed together. The upper part B^1 is guided to maintain the rod always vertical. The lower part B^2 of the rod is carried by a bracket b^2 attached to the gun carriage B^3. The parallel-motion linkage comprises two links c, c^1, and two crank arms C, C^1, of which the crank arm C is attached to the fixed baseplate of the gun mounting, and the other crank arm C^1 is rigidly connected to the lower part B^2 of the rod B^1, B^2. The relationship of the parts of the parallel-motion linkage to the training axis X of the gun carriage is shown by Fig. 2. This arrangement ensures that a dead centre is avoided during the training of the gun. The parallel-motion linkage also enables an all-round training of the gun to be obtained. (*Accepted June* 4, 1919.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

126,865. Perkin and Company, Limited, Leeds, and L. C. Perkin, Beeston, Leeds. Hack Saw Machines. (3 *Figs.*) August 2, 1918.—This invention relates to hack saw machines. According to the invention, there is combined with the reciprocating saw frame and its blade, a slotted arm or slide rigidly attached thereto, to which is secured a screw in such a manner that the screw passes through a hole in the framework of the machine, as the saw frame is raised or lowered. On the screw is placed a nut, and the steepness of the thread is such that the nut falls by its own weight. During the cutting stroke, the nut rests on two washers separated by anti-friction balls, so that the saw frame and its guide are free to descend, and by forcing the screw through the nut, causes it to rotate. On the idle stroke, the saw frame and its blade, screw, nut and washers are raised clear of the work. *a* is a stand upon which is mounted the vice *b*. Provision is also made for mounting the arm *c* carrying the weighted saw frame *d*, and a driving shaft *e*, pulleys *f*, *g*, and other parts for reciprocating the saw frame. To the slide *c* carrying

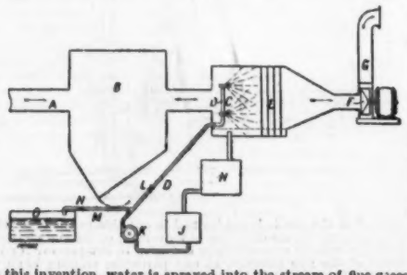




the saw frame *d*, or to an arm *j* rigidly attached thereto, is connected a screw *m*. The screw *m* is arranged to work vertically, as the saw frame *d* is raised or lowered through a hole in the bed *a* of the machine. A nut *p* is placed upon the screw *m*, and the steepness of its thread must be such that the nut falls by its own weight when the screw is held vertically. During the cutting stroke of the saw the nut *p* rests upon two washers, which are separated by a number of balls working in races provided for their reception in the faces of the washers. This arrangement eliminates the friction between the nut and its support, so that the saw frame *d* and its guide are free to descend by forcing the screw through and thereby revolving the nut. During the idle or return stroke of the saw frame *d*, it is raised clear of the work by a cam *s*, fixed upon the driving shaft *e*, acting upon a runner mounted in the bifurcated end of an adjustable carrier *u* secured to the end of a double-ended lever *v*, one end of which is in contact with the nut *p*, whereby the slotted end of arm *j* is raised, carrying with it the screw *m* and nut *p*. (*Accepted May* 28, 1919.)

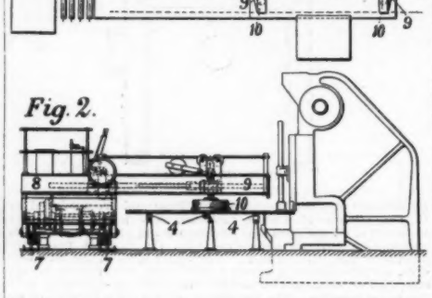
MINING, METALLURGY, AND METAL WORKING.

127,095. F. W. Davis, Magheramorne. Treatment of Flue Gases. (1 *Fig.*) May 21, 1918.—This invention relates to the treatment of flue gases charged with steam. According



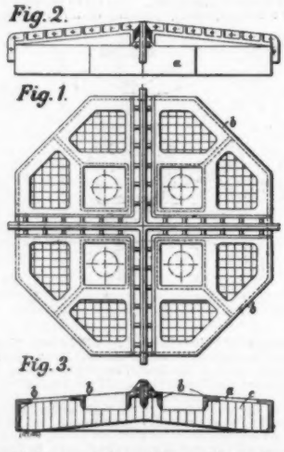
to this invention, water is sprayed into the stream of flue gases so that the temperature of the gases is reduced below the boiling-point of water, but no substantial quantity of the steam contained in the flue gases is condensed. The flue gases pass from a flue A into a chamber B, in which the heavier particles of dust are deposited. From the chamber B the gases pass into another chamber C, where they meet sprays of water issuing from a pipe D, the quantity of water being so regulated that the temperature of the gases is reduced below the boiling-point of water but no substantial quantity of the steam contained in the gases is condensed. The gases and steam pass through baffle plates E to a fan F into an uptake G leading into the air. Any dust and soluble matters contained in the gases are carried to the bottom of the chamber C by the water, and from the chamber C they pass through a filter H and a surface cooler J to a pump K. The water is returned again through the pipe D to the chamber C, a cock L in the pipe D being open. When the water has become sufficiently saturated with soluble matter, the cock L is closed and the water is pumped through a pipe M past a cock N, which has been opened, to a cooling tank O in which the solids in solution crystallise and can be removed and dried without the application of heat. The insoluble dust is collected in the filter H. (*Accepted June* 4, 1919.)

127,065. T. Thomson, Scunthorpe. Metal Plates. (7 *Figs.*) February 19, 1918.—This invention has relation to the handling, manipulation or transportation of metal plates in relation to machinery or apparatus. Machinery or apparatus for the purpose as specified and in accordance with this invention comprises a carriage or a pair of independent carriages 8 mounted to run upon a track 7 or on tracks either on or above the ground, a jib or extension 9 of rigid construction mounted on the carriage or on each of the carriages 8, an electro-magnet 10 or electro-magnets mounted on each of the jibs or extensions 9, means for moving the carriage or carriages on the track or tracks and means for moving the electromagnet or electromagnets along each of the jibs or extensions above the face of the plate to be



handled, manipulated or transported independently of the movements imparted to the carriage or carriages. Further, in accordance with this invention, machinery as described is used in combination with friction reducing means comprising a bed or plurality of rollers or castors 4, or both, said friction reducing means being arranged either at ground level or at a convenient height there above. When the carriages are mounted to run on a track laid upon the ground, they are capable of movement only in two directions, but when the track upon which they run is mounted on what may be called a secondary carriage which is itself mounted to run on a track at right angles to that of the track it carries, the two carriages are capable of simple or compound movement. (*Sealed.*)

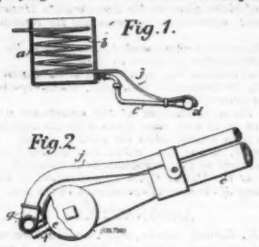
127,105. W. H. Wright, Dunston-on-Tyne, and E. Fenton, Rowlands Gill. Furnace Doors and Roofs. (6 *Figs.*) May 24, 1918.—This invention relates to furnace doors and roofs. According to this invention, a mould is made according to pattern, in which the bricks are placed. Metal is then poured into the mould, and as it cools and contracts the bricks are pressed tightly



together and held securely in position, and in use do not become loose and dislodged by heat from the furnace. The metal may be arranged to run between the bricks in places where desired, to further ensure the individual security of the bricks. *a* is a frame provided with flanges *b*, *b*, *b*; *c*, *c*, *c* are firebricks. (*Accepted June* 4, 1919.)

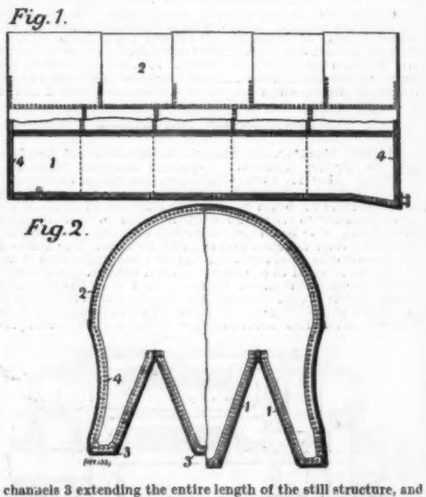
MISCELLANEOUS.

126,789. E. Williams, Leigh, Lancaster. Tar Spraying Roads. (3 *Figs.*) May 15, 1918.—This invention relates to apparatus for spraying tar upon roads, and comprises a drum connected to the tar container and provided with delivery outlets, and a steam nozzle connected to a steam coil situated in said container and provided with corresponding apertures arranged in line with and opening at right angles to said delivery outlets so that the streams of tar issuing therefrom are acted upon by the jets of steam and thereby broken up and the tar sprayed uniformly upon the road. *a* is a tank for containing the tar and conveniently mounted on a trailer drawn by a steam road roller. Within the tank *a* is arranged a steam coil *b* for maintaining the tar at a proper consistency. From the tank *a* the tar is conducted by a pipe *c* to a spraying device *d*. The device *d* comprises a drum *e*



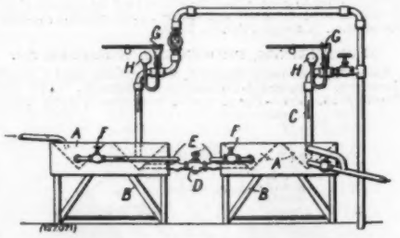
into which the pipe *c* opens, this drum being provided with delivery nozzles *f* and a steam nozzle *g* having apertures arranged in alignment with and opening at right angles to the nozzles *f*. Steam is led from the coil *b* to the nozzle *g* by a pipe *j*. As the streams of tar issue from the delivery nozzles *f* they are acted upon by the jets of steam, the streams being thereby broken up and the tar uniformly sprayed upon the road. (*Accepted May* 28, 1919.)

127,133. W. J. Reid, Gartsherrie, Coatbridge. Tar Still. (2 *Figs.*) June 21, 1918.—According to the invention, the flue plates of the still are riveted along their lower edges to splayed channels extending the entire length of the still structure, and are riveted at their forward or rearward edges to angle frames. The flue plates 1, which are of flat formation, extend the entire length of the still structure 2, being set in inverted V fashion, the lower edges of the plates being riveted to splayed



channels 3 extending the entire length of the still structure, and the forward and rearward edges being riveted to angle frames 4 at the forward and rearward ends of the still structure. In practice, there are two flues, such as shown, so that four flue plates 1 are provided, there being three splayed channels 3 of which the middle channel is riveted to the lower edges of the two middle flue plates 1, and each other channel is riveted to the lower edge of an outer flue plate 1 and to the lower edge of the still structure 2. (*Accepted June* 4, 1919.)

127,071. R. Bowman, Penketh Grange, near Warrington. Evaporating Apparatus. (3 *Figs.*) April 16, 1918.—The present invention relates to evaporating devices comprising vessel open to the atmosphere and containing heating pipes. According to the present invention, the heating pipes are laid loosely in open evaporating troughs and connected with the source of heating medium by flexible or detachable connections, thereby allowing any of the pipes to be bodily removed as a unit from the liquor in the vessels, so that their complete surfaces can be cleaned. A, A are V-shaped troughs supported by light



trestles B. In a pair of troughs a steam pipe C dips down into one of them from above, runs along near the bottom to the end, turns round in a short connecting branch to the other trough and runs along the bottom of this again to the end. The other two troughs are similarly arranged, and they are connected by a coupling D. The steam pipes can be coupled or separated as desired through the pipes E, E, and valves F. The liquor is supplied at one end of the system, as shown by the arrows, while the steam is admitted at the opposite end. G is a safety valve and H a pressure gauge at the entrance to each steam pipe. (*Accepted June* 4, 1919.)